O'BRIEN & GERE

Transmittal

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5000 Cedar Plaza Parkway / Suite 211 / St. Louis, MO 63128 / 314-842-4550

To: Mark Reavis
USEPA
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Date: April 30, 1986

File: 3050.005

Re: NLCC

Gentlemen: We are sending you __X__ herewith _____ under separate cover

_____ drawings __X__ descriptive literature _____ letters

Quan.	Identifying Number	Title	Action*
2	February 1986	Ground Water Quality Assessment	

*Action lettercode: **R**-reviewed **N**-reviewed and noted **I**-for your information
S-resubmit **J**-rejected **Y**-for your approval

Remarks:
Two copies of the Groundwater Assessment Report on Nixdorff Lloyd Chain Company are enclosed for your review. Please call when you've had time to review.

If material received is not as listed, please notify us at once.

cc. R. N. Schulte

RECEIVED
MAY 05 1986
USEPA, RCRA Branch

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.

Joseph Fiala

Joseph Fiala

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Report

Ground Water Quality Assessment

Nixdorff Lloyd Chain Company Maryville, Missouri

Nixdorff Lloyd Chain Company
Maryville, Missouri

February 1986

O'BRIEN & GERE

3050.005

REPORT

GROUND WATER QUALITY ASSESSMENT
NIXDORFF-LLOYD CHAIN COMPANY
MARYVILLE, MISSOURI

APRIL 1986

O'BRIEN & GERE ENGINEERS, INC.
5000 CEDAR PLAZA PARKWAY
SUITE 211
ST. LOUIS, MISSOURI 63128

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APPENDICES

SECTION 1 - INTRODUCTION

1.01 Background

From the early 1970's to the Fall of 1981, a surface impoundment owned by the Nixdorff-Lloyd Chain Company (NLCC) in Maryville, Missouri was used as a depository for process wastes. The process wastes were generated during the production of low carbon steel chains. The principal contributor to the impoundment was the pickling operation where waste pickle liquor from plating operations and caustic rinses were generated. Spent pickle liquor from steel finishing operations is a listed hazardous waste per regulations promulgated by the Resource Conservation and Recovery Act of 1976 (RCRA). As a recipient of listed hazardous wastes, the surface impoundment became a treatment, storage or disposal facility (TSDF) and subject to regulation under the RCRA program.

No discharges to the lagoon have been made since October 14, 1981, when the pickling operation was discontinued. Presently an in-plant treatment facility is used to reduce and neutralize process wastes. The lagoon's contents were neutralized and decanted in November of 1984. NLCC awaits final Missouri Department of Natural Resources (MDNR) approval before completing closure activities.

Four wells were installed in 1982 by NLCC to fulfill RCRA ground water monitoring requirements for a surface impoundment per 40 CFR 265 Subpart F. Subsequent collection and analysis of ground water samples from the wells was completed. Analytical results indicated a statistically significant increase in RCRA ground water indicator parameters hydraulically downgradient per the USEPA student's test statistical data evaluation method. These results were reported to personnel from USEPA Region 7.

The owners of the surface impoundment were directed by USEPA Region 7 to develop and submit a proposed Ground Water Quality Assessment Plan (GWQAP) per 40 CFR 265 Subpart F. A proposed GWQAP was submitted in November 1984. Final approval of the plan was granted by USEPA Region 7 in November 1985.

This report serves to document the investigatory activities completed as part of the GWQAP. Additionally, discussions regarding the site geology and ground water hydrology are included. Ground water chemistry is evaluated relative to the identifiable effects caused by the surface impoundment. This report is submitted in fulfillment of the requirements of 40 CFR 265.93.

1.02 Investigation Scope

The investigation scope of the GWQAP was designed to accomplish two primary objectives. These were:

1. Evaluate the contribution of the inactive surface impoundment to the observed elevated indicators of ground water contamination at existing downgradient wells.
2. Determine of the horizontal and vertical extent of observed elevated ground water contaminant indicators.

Several different work tasks were completed to meet the above study objectives. Specifically these included:

1. Completion of a non-contacting fixed spacing electromagnetic geophysical survey.
2. Installation of additional ground water monitoring wells.

3. Ground water elevation measurements and in-situ hydraulic conductivity testing.

4. Ground water quality sampling and analysis.

Prior to implementing the GWQAP representatives of the owner and personnel from USEPA Region 7 agreed to its objectives and scope in a number of phone conversations held between the period September 1985 and November 1985.

SECTION 2 - REGIONAL PHYSIOGRAPHY

2.01 Topography and Drainage

The NLCC facility is located in the SE¼SW¼ section 16, Polk Township (T64W,R35W), Nodaway County, Missouri and situated west of and within the flood plain of the One Hundred and Two River. A topographic site location map is included as Figure 1. The flood plain is relatively low relief with elevations ranging between 295 and 305 feet above mean sea level (msl). To the west of the site, the land surface changes to more moderate relief with elevations range from 305 to 340 feet msl. From the topography, it is evident that the surface water drainage in the vicinity of the site flows generally due east, towards the river.

2.02 Geology

Regional surfacial features are the result of Kansan Glaciation which took place in the early to middle Pleistocene. Unconsolidated deposits consisting of outwash silts, sands, and gravels and glacial tills underlie the area. A thickness of approximately 80 feet was reported at the location of an on-site supply well (Appendix B) although it is not known if the unconsolidated zone was fully penetrated. Consolidated sedimentary bedrock of the Pennsylvanian Age Virgilian Series exist beneath the unconsolidated deposits (AAPG; Mid-Continent Region Geologic Map; 1966).

2.03 Area Land Uses

The manufacturing building of NLCC faces U.S. Highway 136 near the south property line (Figure 1). Included in this building area is a shipping and storage warehouse. The lagoon area is located at the western property line several hundred feet from the highway. The majority of the northern half of the site is open field which has been farmed in recent years.

The corporate limits of Maryville, Missouri lie within a half mile to the west of the site. A Missouri Highway Department facility is located on an adjoining parcel of land due west of the site. This facility stockpiles de-icing road salt and road tar on the property.

Two power substations are located in the vicinity of the site. One of these stations is located directly south of the abandoned lagoon. The larger of the two substations is located across Industrial Road to the east of the site. These features are illustrated in Figure 2.

SECTION 3 - FIELD INVESTIGATIONS

3.01 Terrain Conductivity Survey

A terrain conductivity survey was conducted by O'Brien & Gere Engineers, Inc. (OB&G) personnel between the traverse lines shown in Figure 2. A Geonics, Ltd. Terrain Conductivity Meter (Model EM-31) was used to complete this survey. The purpose of this task was to assist in detecting and determining the limits of the previously detected high conductivity shallow ground water in the vicinity of the closed lagoon. Traverses were conducted radiating eastward from the lagoon. Data from this survey is included in Appendix A.

3.02 Ground Water Monitoring Well Installations

Per the agreed upon work plan, a total of ten monitoring wells were to have been installed at the Nixdorff-Lloyd Chain Company (NLCC) facility for the purpose of monitoring the upper and lower portions of the water table aquifer. Eight of these wells were to be completed as four nested pairs. The other two wells would be deeper wells set adjacent to existing wells MW2 and MW4 to complete nested pairs at these locations.

It is important to note here that the purpose of completing wells MW5S and MW5D was to establish additional upgradient wells. The existing upgradient well MW1 is located a large distance to the north from the impoundment area and, therefore, may not adequately characterize background ground water quality should ground water flow in an easterly direction.

During the completion of the first borehole for the installation of additional ground water monitoring wells MW5S and MW5D, a dense till unit was encountered. Visually, this material appeared to be unsaturated and of low permeability. Completion of subsequent boreholes for additional well installations across the site confirmed the areal extent of this layer. A minimum of seven feet of this till unit was penetrated at all new monitoring well locations (Figure 2). The occurrence of this till layer was somewhat anticipated as it was reportedly encountered at the location of the on-site supply wells.

Due to the occurrence of the low permeability till layer, a field decision was made which modified the GWQAP with respect to the monitoring well installations. The deeper wells were set at the top of the till deposit which resulted in shallower depths than originally anticipated and, therefore, shorter vertical distances between the shallow and deep wells of the nested pairs. At the two well locations (MW7 and MW8) where the saturated thickness of the shallow aquifer was less than 15 feet thick, a single well was installed instead of the originally proposed well nest. As a result of these changes, only eight of the ten proposed monitoring wells were installed.

Boreholes for the eight newly-installed monitoring wells were completed by P.S.I., Inc. using conventional hollow-stem auger drilling methods. Soil samples were collected every five feet or change in formation using split-barrel sampling methods (A.S.T.M. D-1587-67).

Undisturbed samples were collected with Shelby Tubes 5 feet into the till layer at the MW2, MW4, MW7 and MW8 locations. An additional sample was collected 15 feet within this material at MW7. These samples were used to evaluate the grain size distribution and permeability of this till using ASTM methods D-422 and STP 47D respectively.

Each monitoring well installed by OB&G was constructed of 2-inch I.D., 0.010 inch slot, PVC well screen connected to a 2-inch I.D. PVC flush joint threaded riser casing. A washed sand was placed around MW5S and MW6S well screens due to the fine grained material encountered at these locations. The native saturated sand was allowed to collapse around installed well screens in the remaining wells to create a natural sand pack.

A 2-3 foot thick bentonite seal was placed above the sand packs, and the remaining annulus was filled with bentonite/cement grout. A four-inch locking steel cover was then placed over the well and cemented in place. Specific well installation details are presented in Appendix B.

All drilling and sampling equipment that may have come in contact with potentially contaminated material was decontaminated using a high pressure steam cleaner followed by a control water rinse. Water generate during decontamination was disposed of on the ground surface adjacent to the well site.

Newly completed monitoring wells were developed using air surging methods. The development process was continued until each well yielded sediment free water. Water from well development was discharged onto the adjacent ground surface at each well.

3.03 Ground Water Quality Monitoring and In-Situ Permeability Tests

Ground water samples were collected from each of the monitoring wells on Wednesday, November 13, 1985 and December 18, 1985 by OB&G personnel. Prior to collection of the samples, ground water elevation measurements were made. These elevations are summarized in Table 1. Each of the monitoring wells were then evacuated using a centrifugal pump with dedicated hoses for the first sampling event and stainless steel bailers for second round of ground water samples. The wells were allowed to recover at which time samples were collected using a stainless steel bailer attached to polypropylene cord. The bailer was decontaminated after each use with an acetone wash followed by a control water rinse. New polypropylene cord was used for each well in order to avoid cross contamination.

The samples were placed in containers and packed in coolers with ice for transport to the laboratory for analysis. The samples were analyzed for pH, specific conductivity, fluoride, nitrate, chloride, lead, zinc, iron, chromium, sodium, sulfates, total organic carbon, total organic halides and volatile halogenated organics. These parameters were selected as those which best represent the historical content of the lagoon. All analytical procedures were in accordance with accepted EPA protocols. Chain-of-Custody procedures were followed. Ground water analytical results are summarized on Table 2. Specific analytical methods used are also indicated on Table 2.

In-situ permeability tests were conducted in all of the monitoring wells except MW1. The method used for this test involved rapidly evacuating a volume of water from the well to create a hydraulic difference between the well and the surrounding aquifer. The recovery rate of the water level in the well was then monitored. The value for the hydraulic conductivity at each well location was then calculated using Hvorslev's formula, an acceptable method for single well hydraulic conductivity tests. These data are included as Appendix C.

SECTION 4 - SITE HYDROGEOLOGY

4.01 Site Geology

Newly constructed ground water monitoring well borehole logs have been used to construct cross sections to depict the sites subsurface lithology. The locations of the cross sections are shown on Figure 2. Cross sections are illustrated on Figures 3 and 4. Review of the cross sections and monitoring well boring logs (Appendix B) indicates that three different subsurface units are distinguishable.

Silt with clay and some sand occurs at the surface and extends to a depth of between 11 and 19 feet below ground level. The color of this unit varies from green to gray to red brown with frequent iron stains. Saturation was observed 5 to 7 feet below the land surface.

Beneath the silt layer, interbedded fine to coarse grain sand occurs. This material is gray in color, saturated throughout and becomes less sorted with depth. This is the formation in which the two on-site water supply wells are screened (Appendix B).

Silt and clay glacial till underlies the sand formation. This unit occurs at a depth of between 26 and 35 feet below ground level. Traces of coarse sand were noted throughout this formation mixed into the silt and clay matrix. The unsorted and unstratified nature of this unit is typical of glacial tills. This formation is also identified in an available well log for the supply wells and indicates that the till extends to a depth of 80 feet. Given this significant thickness and that the unit was encountered throughout the site, it is apparent that the till represents a local and likely regional aquiclude that defines the lower boundary of an upper unconfined (water table) aquifer.

4.02 Ground Water Hydrology

Ground water elevations have been recorded on three separate occasions since the completion of the additional monitoring wells. These data are summarized in Table 1. Data recorded on November 13, 1985 have been used to construct Figures 5 and 6; generalized ground water elevation contour maps for shallow and deep wells respectively.

As shown in Figure 4, horizontal ground water flow is generally east-southeast. In the vicinity of the lagoon, however, a diverting flow pattern is apparent. This pattern of constructed ground water contours is strongly influenced by the relatively high ground water elevation observed at Well MW3. Although the high ground water level at MW3, as compared to adjacent well groups MW2 and MW4 which have water levels consistently 3 to 4 feet lower, cannot specifically be accounted for, it is likely that localized ground water mounding is occurring. This may be caused by the lagoon serving as a localized recharge area due to surface ponding of precipitation (as it is out of service and not receiving a hydraulic load from wastewater). This ground water mound, for an unknown reason, is slightly elevated in the area of MW3. This effect will not likely continue subsequent to final covering and closure of the impoundment. Further hydraulically downgradient the diverting flow pattern becomes less apparent and returns to a predominantly east-southeast direction.

Figure 5 illustrated the interpretes ground water flow pattern using data from monitoring wells installed at the base of the water table aquifer. Review of this interpretation indicates that flow direction is due east under a relatively shallow hydraulic gradient of 0.008 ft/ft. A deep monitoring well at the location of MW3 is not available to determine if the deeper portion of the water table is influenced by recharge from the impoundment area. By removing this data point, however, a ground water flow pattern likely more representative of regional ground water is apparent. This predominant easterly flow direction is consistent with local surface drainage and physiographic condition with particular regards to the position of the One Hundred and Two River approximately one mile due east. This river channel likely serves as a regional discharge boundary for shallow ground water.

Recalling earlier discussions, it was stated that the previously existing well MW1 was likely unsuitable to serve as an upgradient well as it far removed from the upgradient flow path and water passing through MW1 would not pass near or beneath the impoundment. It is apparent from the above discussion and in particular, Figures 5 and 6 that the newly established MW5 group is better able to evaluate background ground water quality as it is located nearer in the upgradient flow path of the surface impoundment.

Results of the in-situ hydraulic conductivity test completed are summarized on Table 1. Raw data is included in Appendix C. Review of Table 1 indicates that the horizontal hydraulic conductivity for upper silt formation and the underlying unsorted sand unit range between 0.5 GPD/ft^2 (2.4×10^{-5} cm/sec) and 42.4 GPD/ft^2 (2.0×10^{-3} cm/sec). These end range values are each approximately three times lesser or greater respectively than the next calculated values. Referring to Table 1, if these low and high values are disregarded, the remaining results very near each other averaging 7.4 GPD/ft^2 (3.5×10^{-4} cm/sec). This value is reasonable for the type of subsurface material observed, i.e., silts and sands.

Although the differences in grain size of the two upper formations are distinguishable in the field, the variability their hydraulic conductivities is minor and suggests that they function as a single hydraulic unit.

Ground water flow velocity across the site has been estimated using a modified Darcy's Law expression to calculate lineal velocity.

$$V = \frac{KI}{7.48Sy}$$

where:

V = average lineal velocity
K = hydraulic conductivity (7.4 GPD/ft^2)
I = hydraulic gradient (0.008 ft/ft)
Sy = effective porosity (estimate 0.25 for silt and sand)

then:

$$V = \frac{7.4 \times 0.008}{7.48 \times .25}$$

$$= 0.03 \text{ ft/day}$$

$$= 11.6 \text{ ft/year}$$

Grain size and vertical hydraulic conductivity test results for glacial till samples are contained in Appendix D. These analyses indicate the till has a low hydraulic conductivity with values averaging 7×10^{-7} cm/sec (0.01 GPD/ft^2). Given its low hydraulic conductivity, the glacial till formation serves as an effective barrier to vertical ground water flow.

4.03 Ground Water Chemistry

Table 2 summarizes the ground water quality results of samples collected on November 13, 1985 and December 18, 1985. Figure 7 graphically illustrates the results at individual shallow well locations of those parameters that showed concentrations above the detection limit. Note that results for lead and cadmium are not shown on Figure 7, as, referring to Table 2, they were not detected above 0.01 ppm. Additionally, it should be pointed out that the concentrations shown on Figure 7 are the highest reported value of the two sampling events and in some cases values shown at a particular well may be results from different sampling times. The illustration is intended to show the spacial distribution of relative concentrations across the site.

Review of Figure 7 and Table 2 indicates that the majority of parameters are observed in the highest concentrations upgradient of the site at MW5 group. Exceptions to this are:

1. Fluoride is elevated compared to that observed at MW5 group, at downgradient wells groups MW4S, MW6S, MW6D, MW7 and to a lesser degree at MW8.
2. Zinc is elevated at MW4 group as compared to MW5 group.
3. Sulfate is elevated at wells MW2S, MW2D, MW3, MW4D, and on one of the sampling occasions, at MW4S and MW8.

The organic indicator TOC (total organic carbon), also was observed in higher concentrations at the upgradient well MW5S in the second set of samples than downgradient.

Figure 8 illustrates the results of the non-contacting terrain conductivity survey completed downgradient of the surface. The survey results appears to have identified the high conductivity ground water directly adjacent to and downgradient of the impoundment. Two other anomalies are apparent; one east of MW2 group and one at the southeast corner of the survey area. Given the proximity of power substations in the area, a large amount of interference exists in the area making it inappropriate to interpret individual anomalies.

From Figure 7 and Table 2, it is apparent that the spacial distribution of both inorganic and organic parameters strongly suggests that an upgradient source of these materials exists. This was preliminarily determined following the review of the second sampling round analytical data. Subsequently, a re-inspection of the area immediately hydraulically upgradient of the site, was completed on February 19, 1986 by personnel from OB&G. The inspection of the property was made from the Norfolk and Western railroad right-of-way. The results of the inspection revealed the presence of what appears to be a bulk road salt storage pile. Additionally, an uncontrolled, unremediated loss of road patching tar is evident at the property fence line. This tar material appeared very viscous, although the ambient temperature was approximately 35°F at the time, and has made its way into a small drainage ditch on the west side of the railroad embankment. Both of these materials, road salt and tar, can contribute to the concentrations of analytical parameters monitored around and downgradient of the inactive surface impoundment. Given the existence of hydraulically upgradient potential sources of ground water contaminants, conclusions cannot be drawn as to the contribution of the monitored water quality parameters attributable to the inactive surface impoundment.

SECTION 5 - SUMMARY AND CONCLUSIONS

5.01 Summary

A Ground Water Quality Assessment Plan (GWQAP) has been completed at the site of an inactive surface impoundment owned by Nixdorff-Lloyd Chain Company and located in Nodaway County, Missouri. The GWQAP was completed in accordance with a work plan approved by USEPA Region 7 as per and in accordance with 40 CFR 265 Subpart F. Specifically, the following investigation work tasks were completed:

1. Geophysical Survey.
2. Ground Water Monitoring Well Installation.
3. In-Situ Hydraulic Conductivity Testing.
4. Ground Water Elevation Monitoring.
5. Ground Water Quality Sampling and Analysis.

This document summarizes in detail the investigation method and procedures and presents interpretations regarding the hydrogeology and local ground water quality.

5.02 Conclusions

The completion of the GWQAP has resulted in the following conclusions:

1. The site is underlain by three identifable unconsolidated deposits which are in descending order:
   a. Silt with clay and sand from the surface to between 11 and 16 feet below ground level.

b. Unsorted sand beneath the silt to a depth of 28 to 36 feet.

c. Glacial till beneath the unsorted sand to an estimated depth of approximately 80 feet.

2. Shallow ground water occurs beneath the site at depths of between 5 and 7 feet.

3. Although visually distinct, similar hydraulic conductivities between the silt and unsorted sand formations suggest they function as a single hydraulic unit. The estimated average hydraulic conductivity for these materials is 7.4 GPD/ft^2.

4. The glacial till underlying the unsorted sand formation has an average vertical hydraulic conductivity of 0.01 GPD/ft^2 (7×10^{-7} cm/sec) and act as a barrier to vertical flow.

5. Ground water flow is in an east-southeast direction across the site under a hydraulic gradient of 0.008 ft/ft and at an estimated velocity of 11.5 ft/day.

6. Ground water quality data suggests an upgradient potential source of inorganic and organic ground water contaminants exists.

7. The ground water quality data base is insufficient to determine to what extent the inactive surface impoundment is contributing the observed concentrations of ground water quality monitoring parameters.

Respectfully Submitted,

O'BRIEN & GERE ENGINEERS, INC.

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Tables

O'BRIEN & GERE

TABLE 1
WELL DETAILS AND HYDROGEOLOGIC DATA
NIXDORFF-LLOYD CHAIN CO.

WELL	TOP OF STEEL CASING ELEVATION *	GROUND SURFACE ELEVATION *	SCREENED INTERVAL *	WELL DIAMETER	HYDRAULIC CONDUCTIVITY-CM/S (GPD/FT^2)	GROUND WATER ELEVATIONS * 11/10/85	11/13/85	12/11/85	2/19/86
1	1027.28	1025.86		4"	----------	------	------	------	1016.01
2S	998.00	995.60	976.17'-986.17'	4"	2.4 x 10-5 (0.5)	------	990.20	989.70	989.72
2D	998.71	995.71	966.01'-971.06'	2"	4.3 X 10-4 (9.1)	------	991.81	991.40	991.69
3	998.14	996.54	979.48'-989.48'	4"	3.7 X 10-4 (7.8)	------	994.44	993.40	993.50
4S	996.60	995.30	976.1'-986.1'	2"	8.2 X 10-5 (1.7)	------	991.30	990.40	990.41
4D	999.43	996.40	962.2'-967.2'	2"	2.6 X 10-4 (5.5)	992.60	992.60	991.70	991.99
5S	1003.80	1000.00	980.2'-990.2'	2"	9.2 X 10-5 (1.9)	994.74	994.60	995.90	995.78
5D	1003.58	999.88	965.18'-970.18'	2"	5.7 X 10-4 (12.1)	994.17	993.98	993.20	993.42
6S	992.72	990.12	970.82'-980.82'	2"	7.0 x 10-4 (14.8)	995.92	986.02	985.50	986.26
6D	992.62	990.26	962.96'-967.96'	2"	2.0 X 10-3 (42.4)	986.26	986.36	985.60	986.12
7	994.68	992.13	966.43'-981.43'	2"	3.0 X 10-4 (6.4)	987.33	987.13	986.10	986.96
8	989.09	994.28	966.98'-981.98'	2"	3.5 X 10-4 (7.4)	989.99	991.48	991.70	991.85

NOTE: * - ELEVATIONS BASED ON ASSUMED DATUM.

TABLE 2
GROUND WATER QUALITY DATA
NIXDORFF-LLOYD CHAIN COMPANY
MARYVILLE, MISSOURI

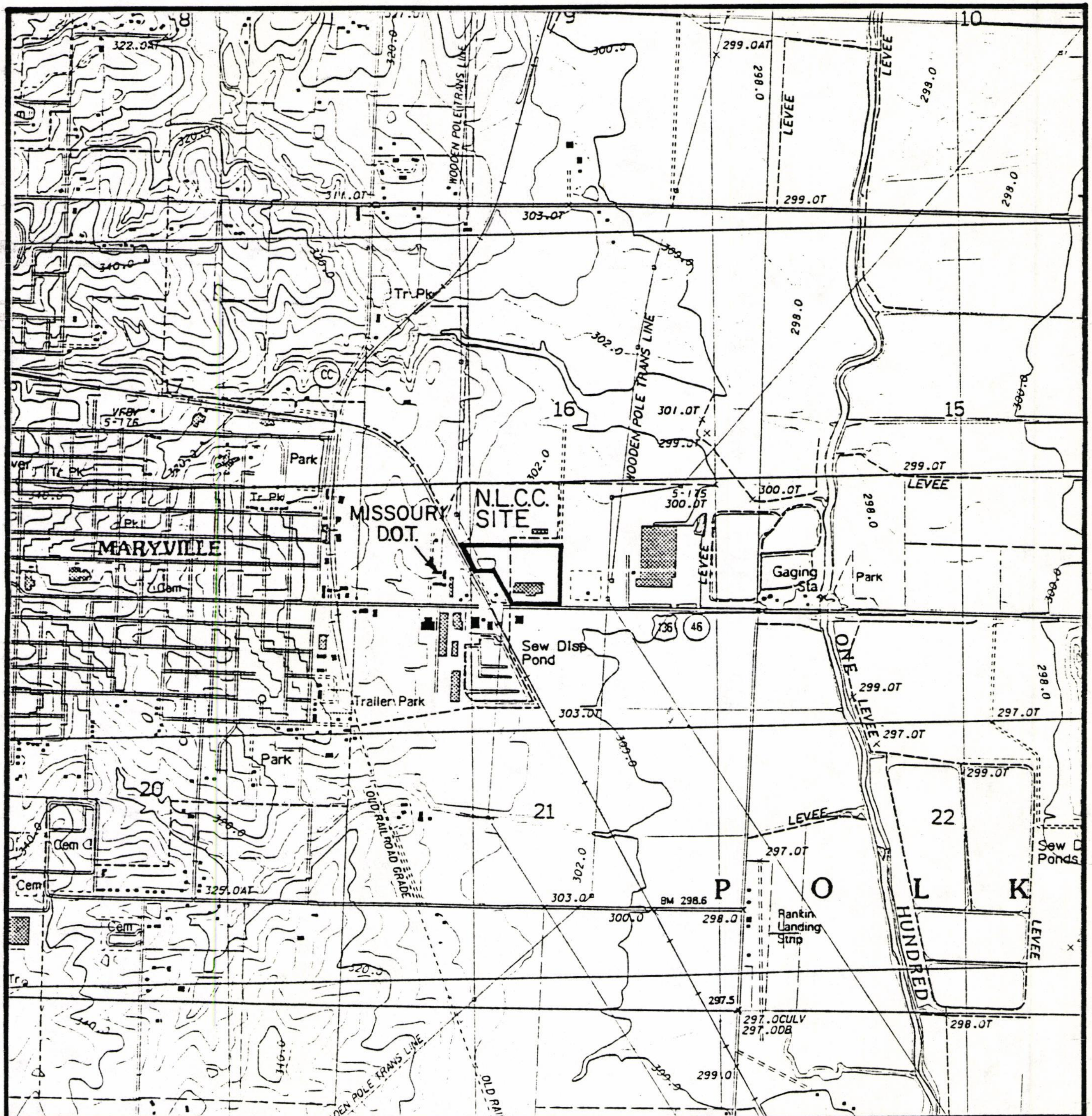
WELL	DATE SAMPLED	PH	SPECIFIC CONDUCTIVITY (UMHOS)	FLUORIDE (PPM)	NITRATE (PPM)	CHLORIDE (PPM)	LEAD (PPM)	ZINC (PPM)	IRON (PPM)	CHROMIUM (PPM)	SODIUM (PPM)	SULFATE (PPM)	TOC** (PPM)	TOX-1* (PPB)	TOX-2* (PPB)
MW1	10/23/84	6.5	340	0.17	5.4	3	NA	NA	0.36	NA	12	31	8	(10	(10
MW2S	11/13/85	6.6	756	0.14	(0.01	118	(0.01	(0.01	0.56	(0.01	26.2	200	11	20	36
	12/18/85	6.8	840	0.19	(0.01	123	(0.01	(0.01	1	(0.01	29	260	6	10	14
MW2D	11/13/85	6.6	730	0.14	(0.01	100	(0.01	0.03	0.28	(0.01	26.3	100	12	31	30
	12/18/85	6.9	630	0.19	(0.01	90	(0.01	(0.01	1.3	(0.01	26	170	7	(10	(10
MW3	11/13/85	6.3	621	0.17	(0.01	118	(0.01	(0.01	0.78	(0.01	22.5	180	23	27	23
	12/18/85	6.7	520	0.19	(0.01	102	(0.01	(0.01	0.52	(0.01	23	96	7	(10	(10
MW4S	11/13/85	5.5	3360	0.39	0.06	490	(0.01	5.4	0.9	(0.01	107	19	14	78	69
	12/18/85	6.1	3040	0.25	(0.01	460	(0.01	2.5	0.17	0.03	116	1730	13	28	47
MW4D	11/13/85	6.9	854	0.17	(0.01	127	(0.01	0.08	0.15	(0.01	36.2	370	11	33	37
	12/18/85	6.7	930	0.18	(0.01	108	(0.01	(0.01	1.2	(0.01	35	200	10	27	14
MW5S	11/13/85	6.7	3310	0.12	(0.01	1180	(0.01	0.04	0.04	(0.01	97	85	12	59	65
	12/18/85	6.5	2800	0.13	(0.01	1670	(0.01	0.01	0.66	(0.01	88	70	173	22	41
MW5D	11/13/85	7.1	709	0.15	(0.01	183	(0.01	(0.01	0.18	(0.01	28.5	16	19	26	26
	12/18/85	7.3	560	0.18	0.03	104	(0.01	(0.01	0.13	(0.01	31	14	83	(10	(10
MW6S	11/13/85	7.0	306	0.25	0.02	51	(0.01	0.02	3.2	(0.01	26	27	28	16	16
	12/18/85	6.4	340	0.35	0.18	21	(0.01	(0.01	1.4	(0.01	24	30	19	(10	19
MW6D	11/13/85	8.2	370	0.46	0.03	9	(0.01	(0.01	1.89	(0.01	32.5	19	22	33	41
	12/18/85	6.9	310	0.36	0.52	6	(0.01	(0.01	2.7	(0.01	28	7	18	17	40
MW7	11/13/85	9.5	255	0.41	0.02	7	(0.01	(0.01	0.14	(0.01	31.6	25	12	15	34
	12/18/85	7.6	320	0.45	0.28	8	(0.01	(0.01	4.5	(0.01	29	20	15	(10	(10
MW8	11/13/85	7.1	682	0.21	0.19	31	(0.01	(0.01	0.09	(0.01	46.2	240	12	31	44
	12/18/85	7.2	420	0.29	0.08	10	(0.01	(0.01	0.72	(0.01	23	57	10	(10	13
EPA METHOD NUMBER ***		150.1	120.1	340.1	353.1	325.2	239.1	289.1	236.1	218.1	273.1	375.3	415.1	450.1 ~	

NOTES: NA - Not Analyzed
** - TOTAL ORGANIC CARBON
* - TOTAL ORGANIC HALIDES (ANALYZED IN DUPLICATE)
*** - FROM EPA 600/4-79-020, Revised March 1983 unless otherwise noted.
~ - USEPA/EMSL November 1980

Figures

O'BRIEN & GERE

FIGURE 1



NIXDORFF-LLOYD CHAIN CO.
MARYVILLE, MISSOURI

N

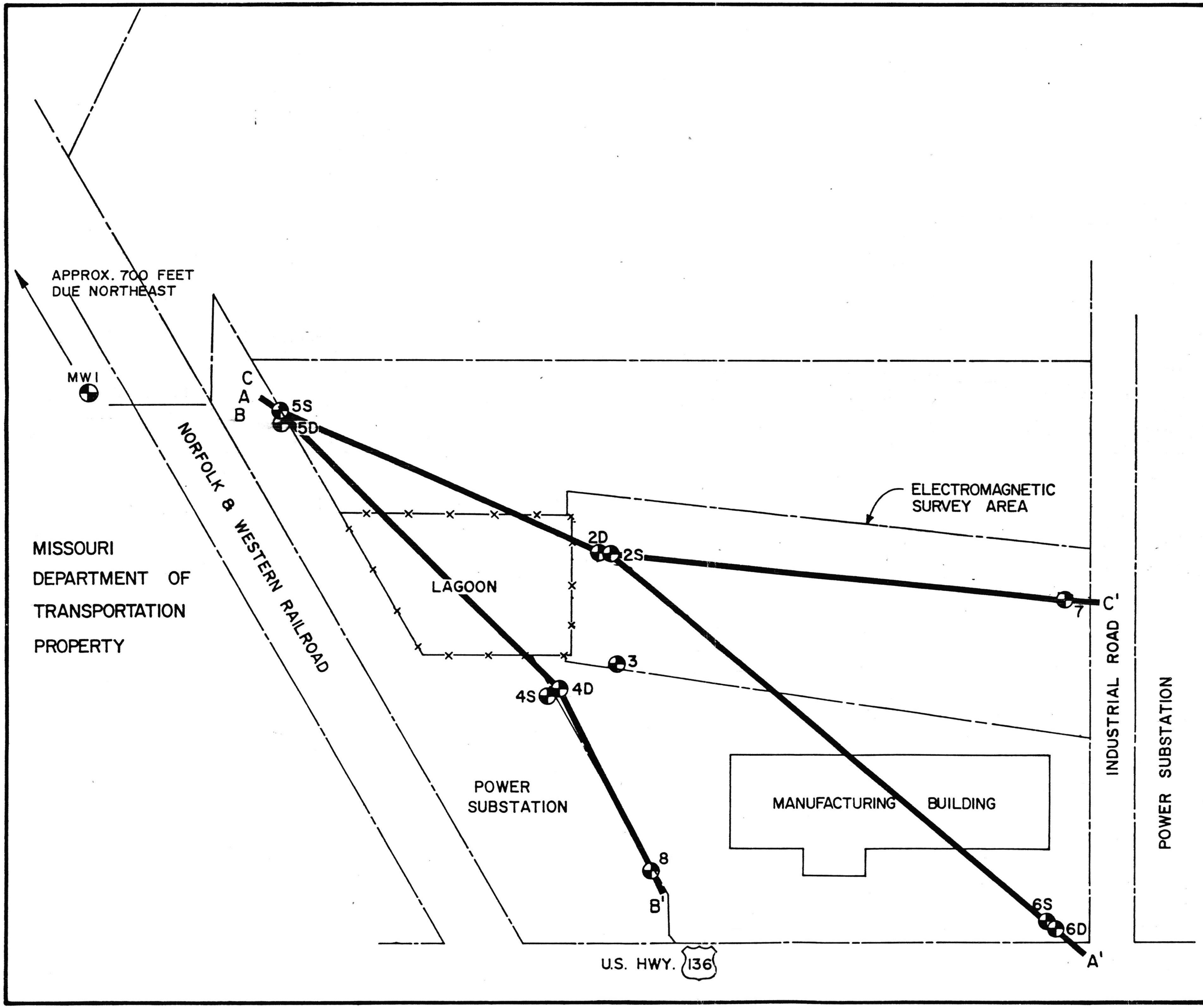
TOPOGRAPHIC SITE LOCATION MAP

ADAPTED FROM U.S.G.S. (7.5 MIN.) MARYVILLE EAST MISSOURI 1985

SCALE 1" = 2000'
CONTOUR INTERVAL **4 METERS**

O'BRIEN & GE

FIGURE 2



NIXDORFF-LLOYD
CHAIN COMPANY
MARYVILLE, MISSOURI

SITE MAP

LEGEND

LEGEND

A—A' CROSS SECTION LOCATIONS

6S MONITORING WELLS

GROUND WATER

SCALE
100 0 100
FEET

O'BRIEN & GERE

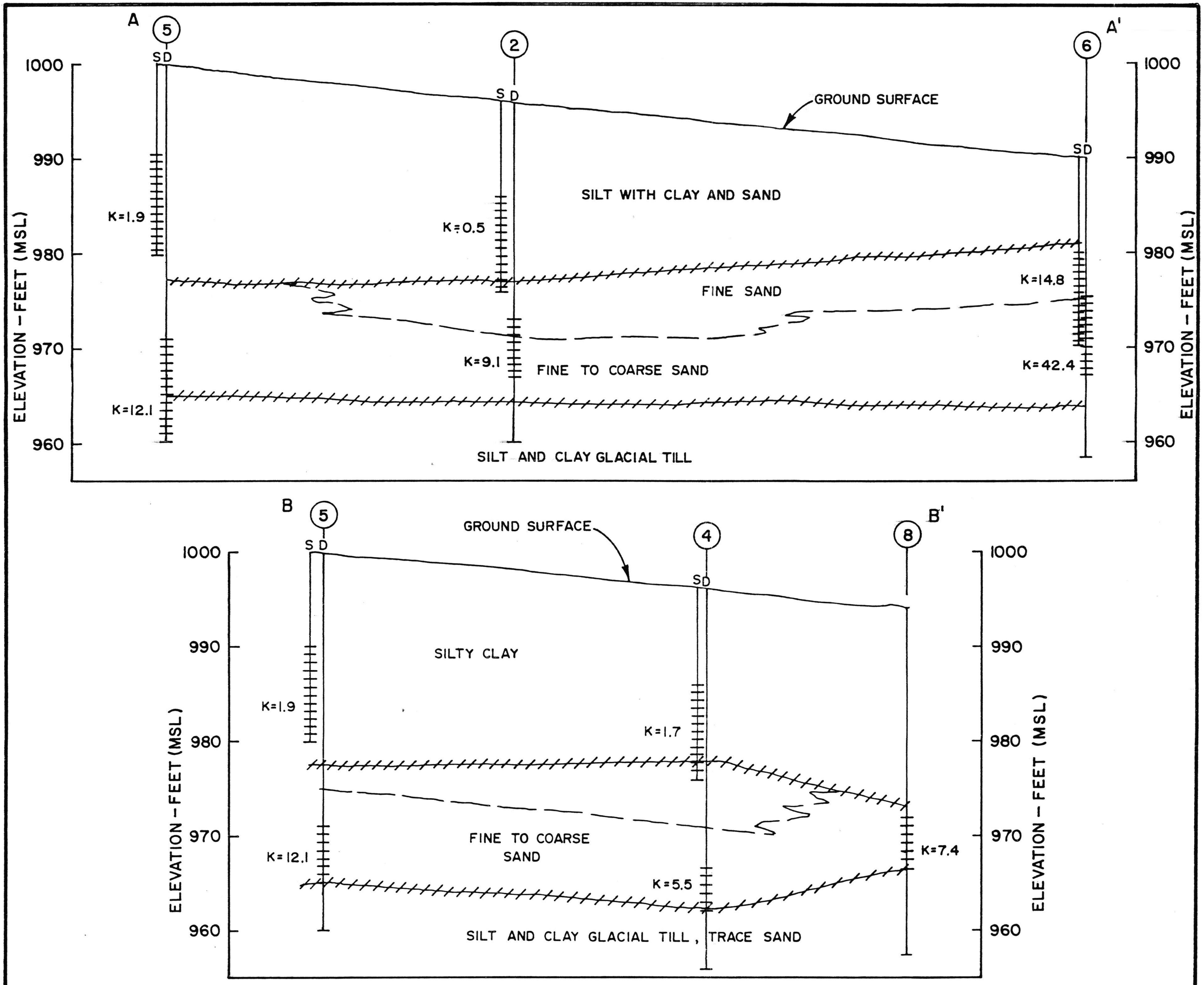


FIGURE 3

NIXDORFF - LLOYD
CHAIN COMPANY
MARYVILLE, MISSOURI

CROSS SECTIONS
A-A' AND B-B'

LEGEND

- LITHOLOGIC BOUNDARY
- 8 WELL NUMBER
- WELL SCREEN
- BORING DEPTH
- S SHALLOW WELL
- D DEEP WELL
- GROUND WATER LEVEL
- K INSITU HYDRAULIC CONDUCTIVITY TEST RESULTS(6PD/FT^2)

HORIZOTAL SCALE

100 0 100 200

(IN FEET)

O'BRIEN & GERE

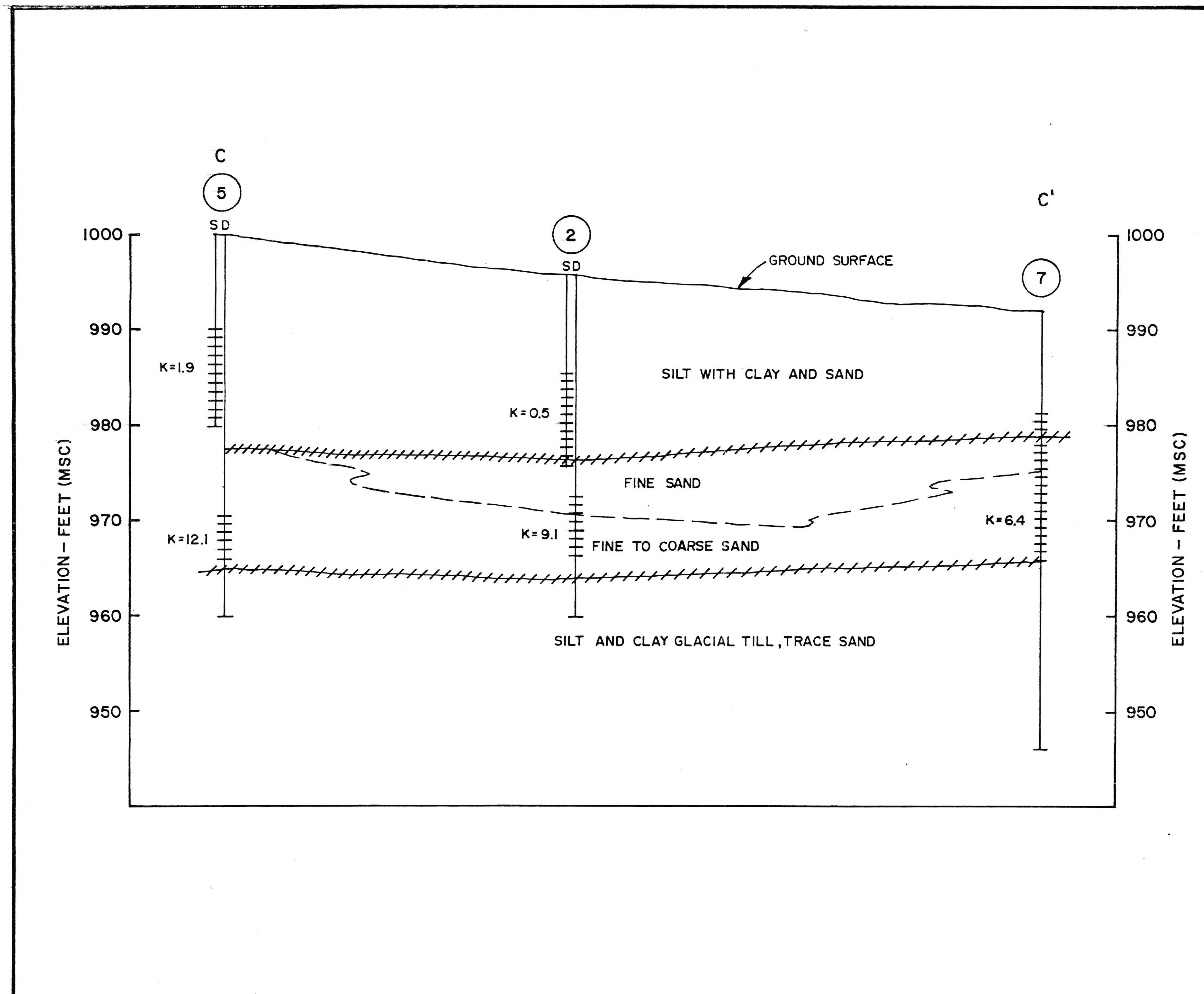


FIGURE 4

NIXDORFF - LLOYD
CHAIN COMPANY
MARYVILLE, MISSOURI

CROSS SECTION
C-C'

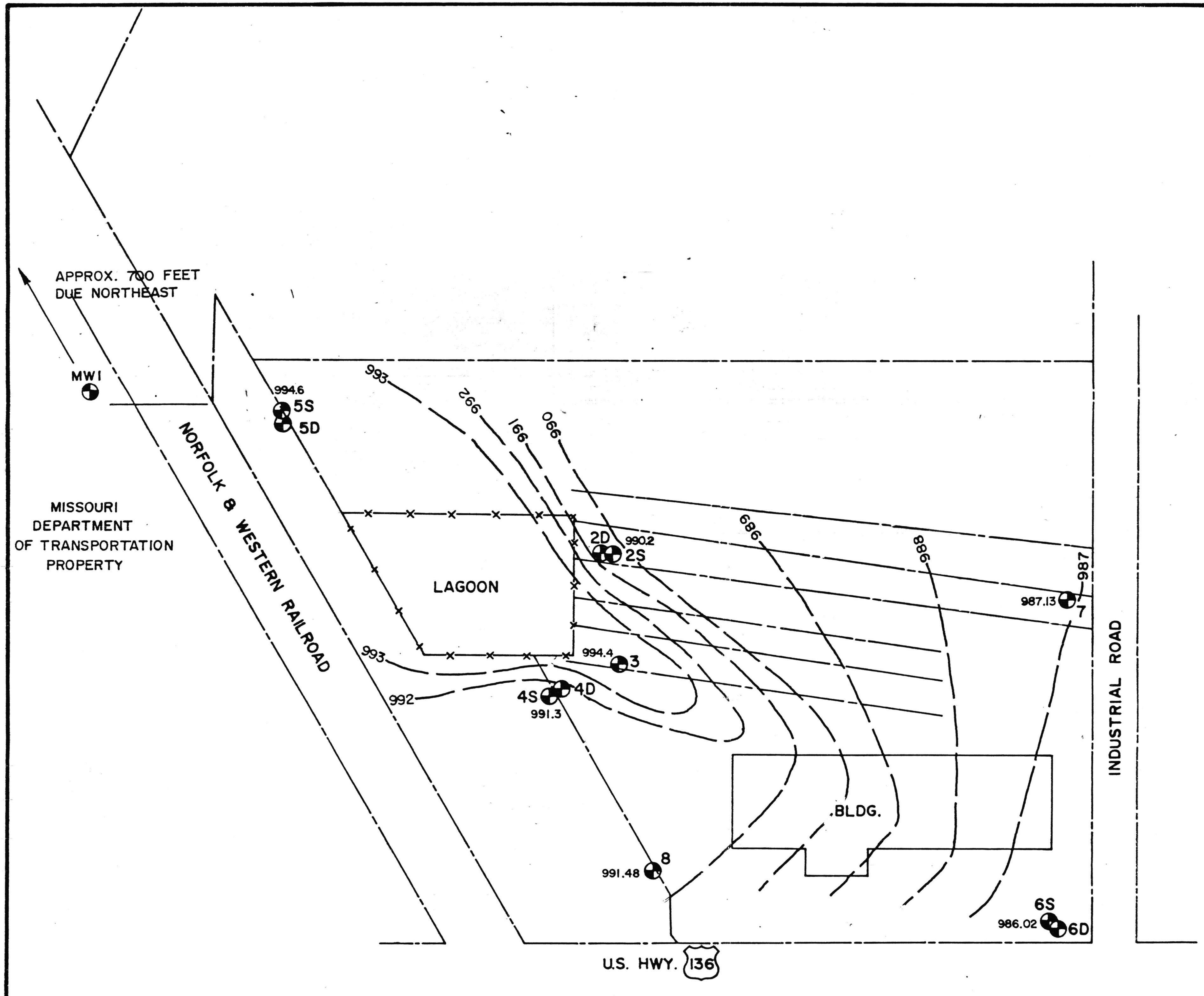
LEGEND

LITHOLOGIC BOUNDARY
(7) WELL NUMBER
WELL SCREEN
BORING DEPTH
S SHALLOW WELL
D DEEP WELL
GROUND WATER LEVEL
K INSITU HYDRAULIC CONDUCTIVITY TEST RESULTS (6PD/FT²)

HORIZOTAL SCALE
100 0 100 200
(IN FEET)

O'BRIEN & GERE

FIGURE 5



NIXDORFF-LLOYD
CHAIN COMPANY
MARYVILLE, MISSOURI

GROUND WATER
ELEVATIONS

SHALLOW WELLS
NOVEMBER 13, 1985

LEGEND

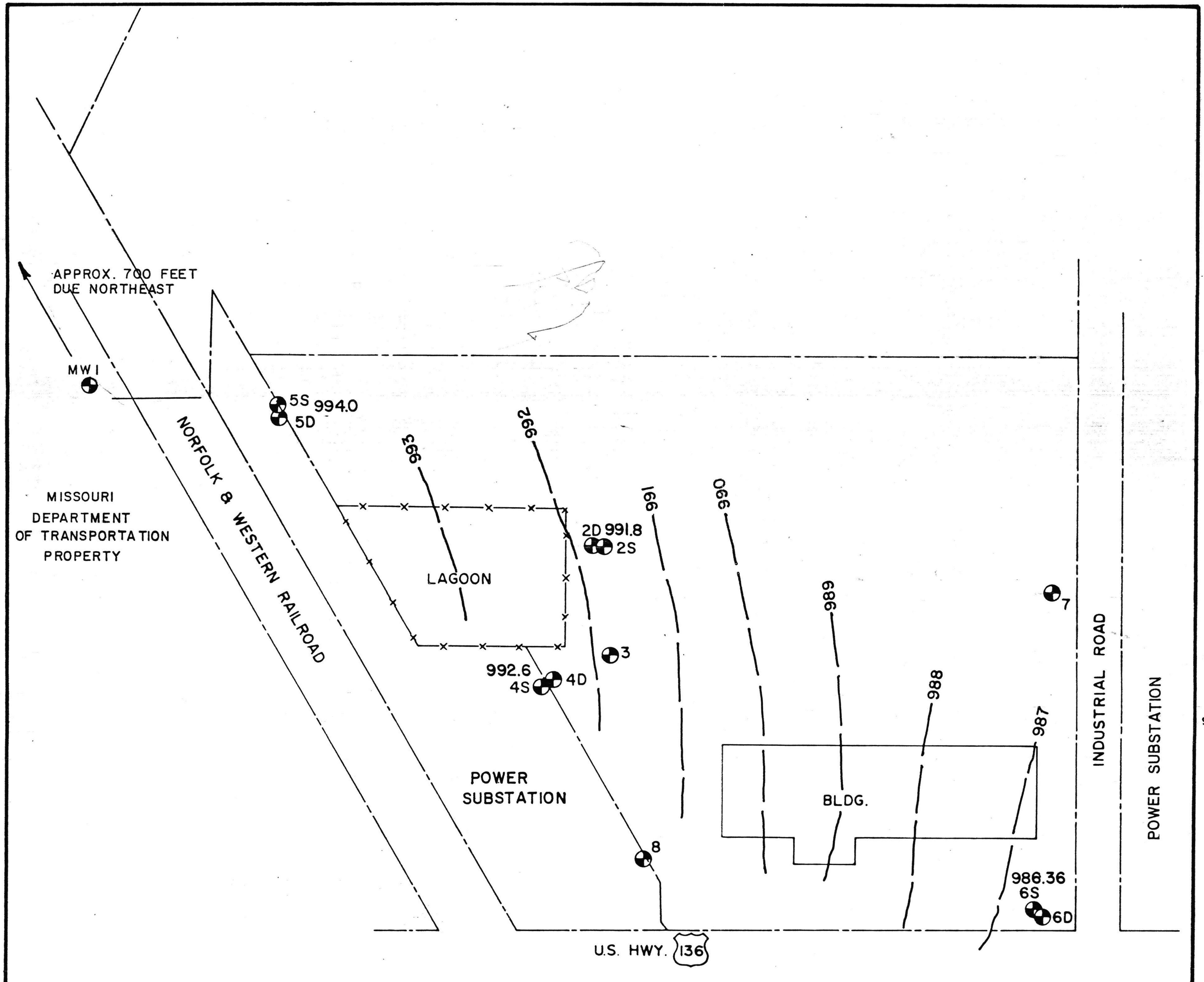
990.2 GROUNDWATER ELEVATION (BASED ON ASSUMED DATUM)

990 CONTOUR LINE

SCALE
100 0 100
FEET

O'BRIEN & GERE

FIGURE 6



NIXDORFF-LLOYD
CHAIN COMPANY
MARYVILLE, MISSOURI

GROUND WATER ELEVATIONS DEEP WELLS

NOVEMBER 13, 1985

LEGEND

991.8 GROUND WATER ELEVATION (BASED ON ASSUMED DATUM)

987 — CONTOUR LINE

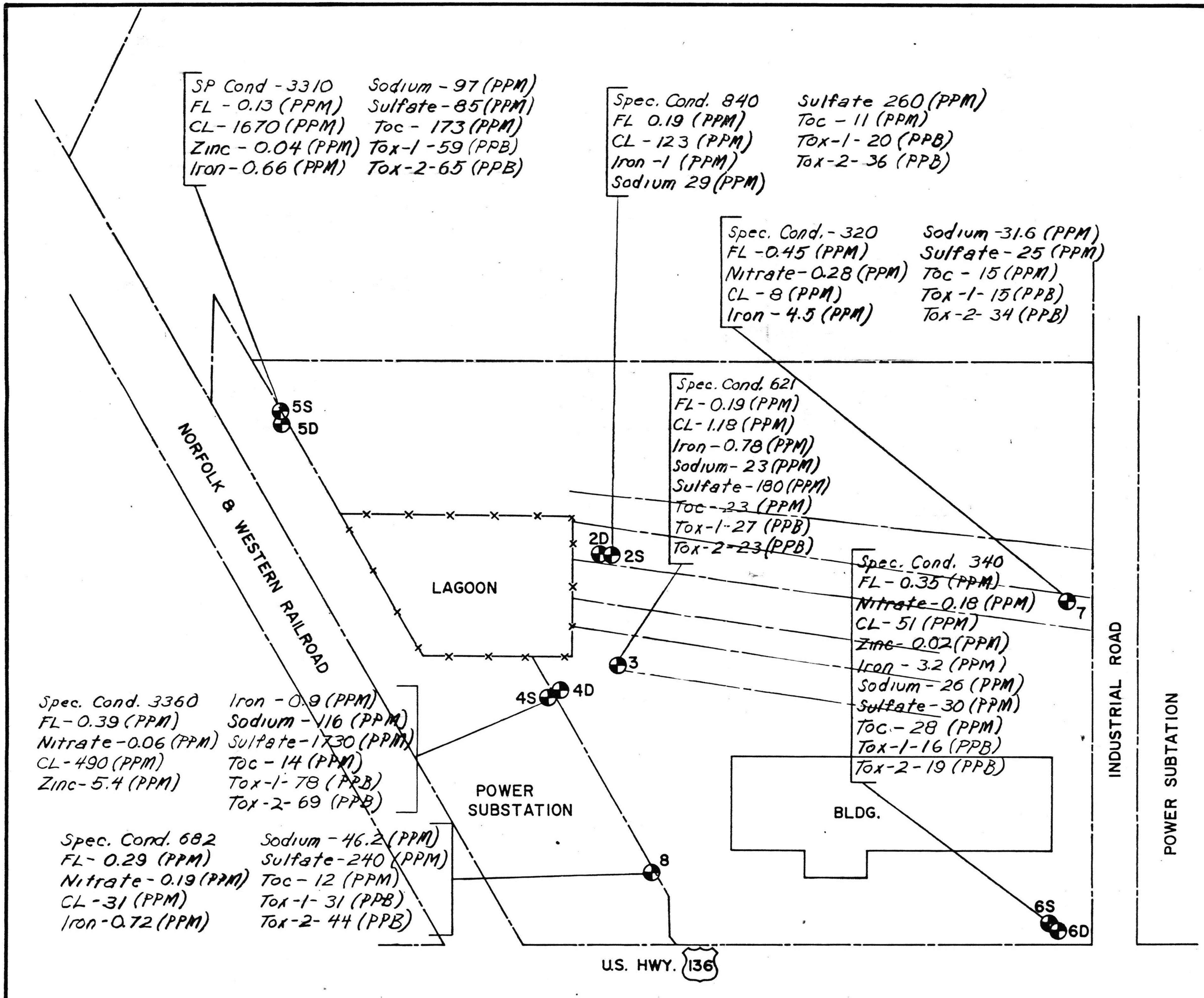
SCALE

100 0 100

FEET

O'BRIEN & GERE

FIGURE 7



NIXDORFF-LLOYD
CHAIN COMPANY
MARYVILLE, MISSOURI

GROUND WATER CHEMISTRY MAP

LEGEND

MONITORING WELL

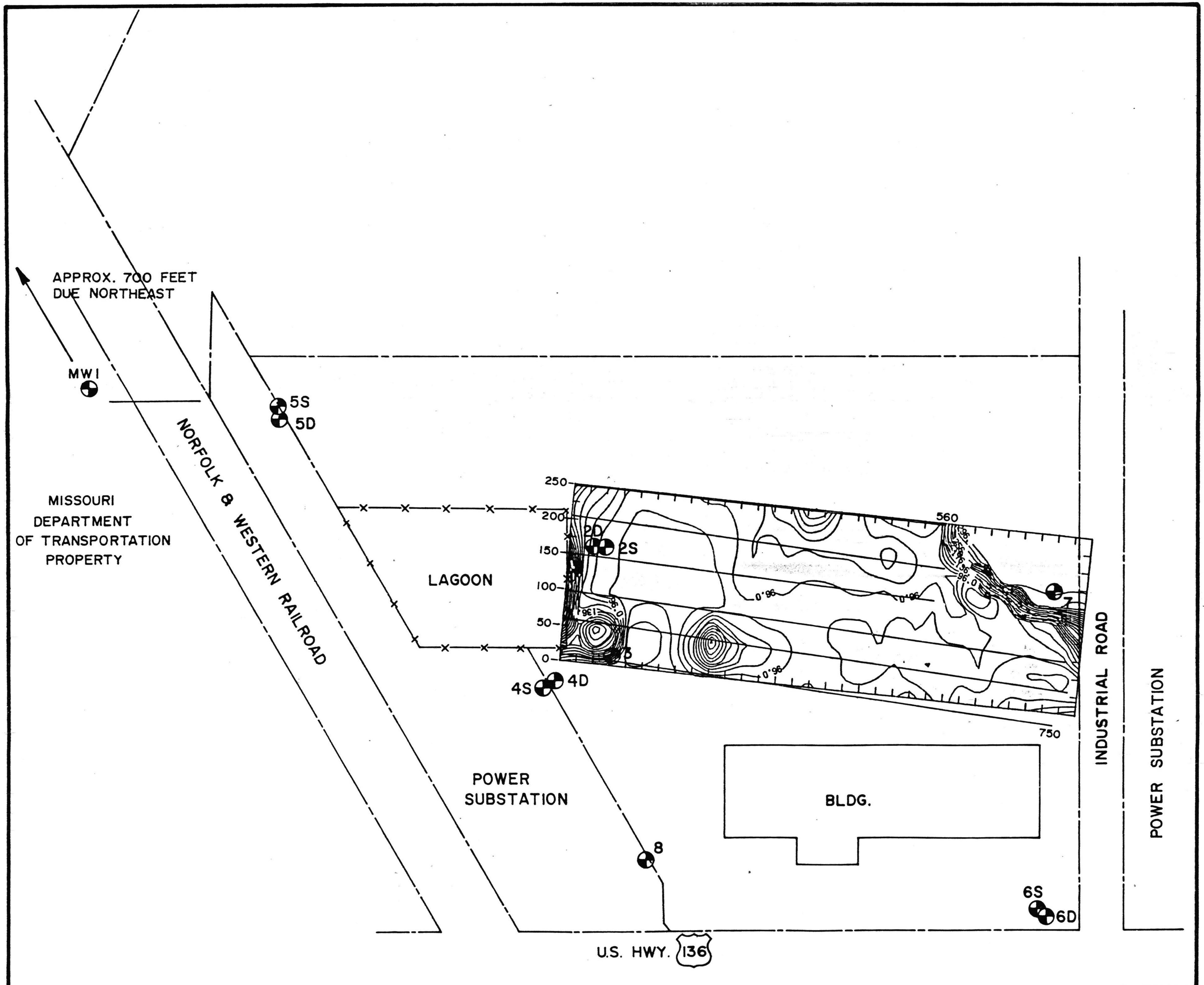
SCALE

100 0 100

FEET

O'BRIEN & GERE

FIGURE 8



NIXDORFF-LLOYD
CHAIN COMPANY
MARYVILLE, MISSOURI
TERRAIN CONDUCTIVITY
MAP

LEGEND

MONITORING WELL

SCALE
100 0 100
FEET

O'BRIEN & GERE

Appendices

O'BRIEN & GERE

APPENDIX A

Terrain Conductivity Data

TERRAIN CONDUCTIVITY SURVEY DATA

```
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SURVEY DATA (Cont'd)

Y X READING

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APPENDIX B

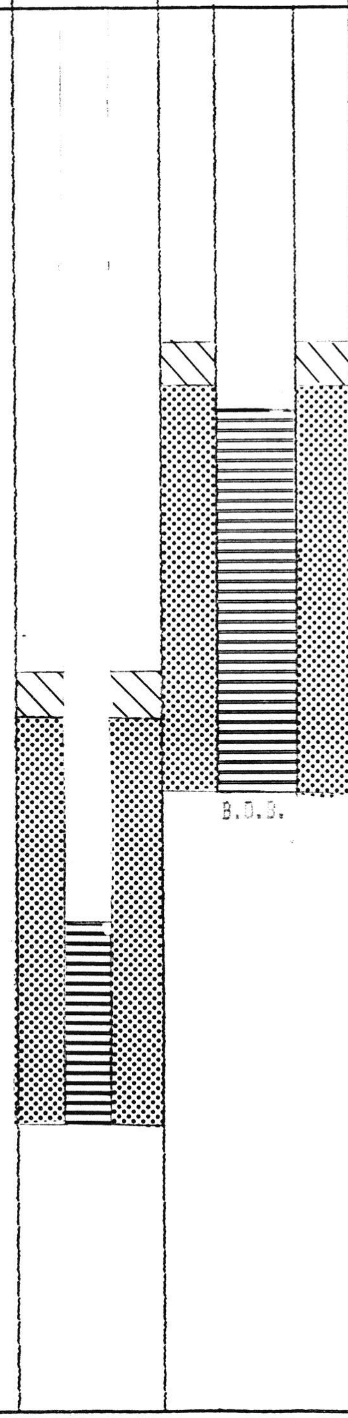
Drilling Logs and Well Details

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. MW 2s, 2d Sheet 1 of 1
Project Location Maryville, Missouri Client: Nixdorff-Lloyd Chain Company	SAMPLER Type: Hammer: Fall:	Ground Water Depth Date Depth - Date - File No. 3050.005

Boring Co. Omaha Testing Division - P.S.I.
Foreman: Scott Kratz
OBG Geologist: Peter Bogardus

Boring Location: Mw 2s, 2d
Ground Elevation:
Dates: Started: 11/8/85 Ended: 11/8/85

Depth	Sample #	Penetrn/ Recovery	Sample Depth	Blows /6"	Sample Description	Stratum Change General Descript	Equipment Installed	Equipment Installed	Rmks*
0'	1		0-1.5	3-4-5	Gray, moist, SILT, some fine Sand, trace Clay				
					3'				
5'	2		5-6.5	3-4-5	Gray-green, moist, SILT, some Clay, trace fine Sand. (iron oxide stains)				
					11'				
10'	3		10-11.5	2-2-3	Red-brown, moist, SILT, some Clay, trace fine Sand. (iron oxide stains)				
					14'				
15'	4		15-16.5	5-8-12	Red-green, moist, SILT and FINE SAND, little Clay. (iron oxide stains) 19				
					19'				
20'	5		20-21.5	8-8-4	Gray, wet, FINE SAND				
					25'				
25'	6		25-26.5	7-13-13	Gray, wet, FINE to COARSE SAND, little fine Gravel				
30'	7		30-31.5	6-7-10					
					31.5'				
35'	8		35-36.5	SHELBY	Gray-black, moist, CLAY, some Silt, trace coarse Sand				

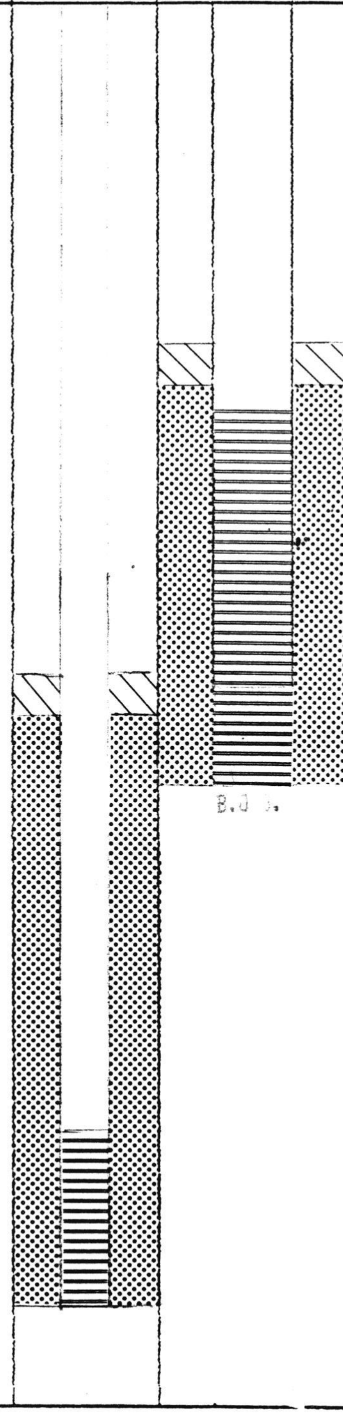


O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. MW 4s, 4d Sheet 1 of 1
Project Location Maryville, Missouri Client: Nixdorff-Lloyd Chain Company	SAMPLER Type: Hammer: Fall:	Ground Water Depth Date Depth - Date - File No. 3050.005

Boring Co. Omaha Testing Division - P.S.I.
Foreman: Scott Kratz
OBG Geologist: Peter Bogardus

Boring Location: MW 4s, 4d
Ground Elevation:
Dates: Started: 11/8/85 Ended: 11/8/85

Depth	Sample #	Penetrn/ Recovery	Sample Depth	Blows /6"	Sample Description	Stratum Change General Descript	Equipment Installed	Equipment Installed	Rmks*
0'	1		0-1.5	6-6-6	Orange-brown, moist, SILT, some fine Sand, trace Clay				
						3'			
6'	2		5-6.5	3-5-6	Gray-green, moist, SILT, some Clay, trace fine Sand. (iron oxide stains)				
						9'			
12'	3		10-11.5	1-1-2	Gray-green, moist, SILT and CLAY, trace fine Sand. (iron oxide stains)				
						15'			
18'	4		15-16.5	2-3-4	Gray-green, moist, SILT, some Clay, trace fine Sand				
						18'			
24'	5		20-21.5	1-1-1	Gray, wet, FINE to MEDIUM SAND				
						25'			
30'	6		25-26.5	8-8-11	Gray, wet FINE to COARSE SAND, little fine Gravel.				
36'	7		30-31.5	7-8-9					
						34'			
42'	8		35-36.5	Shelby	Gray-black, moist, CLAY, little Silt, trace coarse Sand				



O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. MW 5s, 5d Sheet 1 of 1
Project Location Maryville, Missouri Client: Nixdorff-Lloyd Chain Company	SAMPLER Type: Hammer: Fall:	Ground Water Depth Date Depth - Date - File No. 3050.005

Boring Co. Omaha Testing Division - P.S.I.
Foreman: Scott Kratz
OBG Geologist: Peter Bogardus

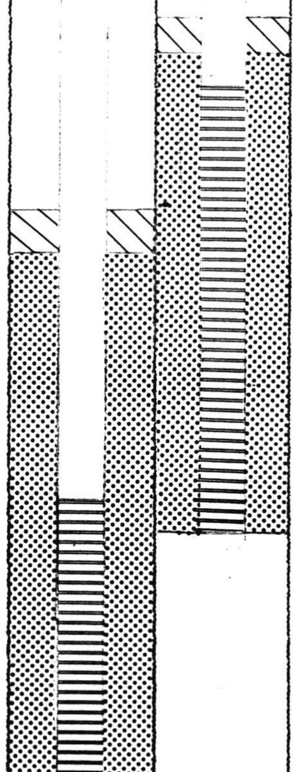
Boring Location: MW 5s, 5d
Ground Elevation:
Dates: Started: 11/5/85 Ended: 11/5/85

Depth	Sample #	Penetrn/ Recovery	Sample Depth	Blows /6"	Sample Description	Stratum Change General Descript	Equipment Installed	Equipment Installed	HNU	Rmks*
0'	1		0-1.5	3-3-4	Gray, moist, SILT, some organics					
					3'					
6'	2		5-6.5	3-4-7	Gray-green, moist, SILT, some Clay, trace fine Sand					
12'	3		10-11.5	2-3-6	-					
					15'					
18'	4		15-16.5	2-2-3	Black, wet, SILT, some fine Sand					
					15.5'					
24'	5		20-21.5	2-3-4	Gray, moist, SILT, some Clay, trace fine Sand. (varved silt and clay lenses)			B.O.B.		
					22.5'					
30'	6		25-26.5	5-4-6	Gray, wet, FINE to MEDIUM SAND -					
36'	7		30-31.5	7-12-17	Gray, wet, FINE to COARSE SAND (1/2 inch silt lense at 31.5 feet)					
					35'					
42'	8		35-36.5	7-10-11	Gray-black, moist, CLAY, some Silt, trace Coarse Sand.					

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. MW 6s, 6d Sheet 1 of 1
Project Location Maryville, Missouri Client: Nixdorff-Lloyd Chain Company	SAMPLER Type: Hammer: Fall:	Ground Water Depth Date Depth - Date - File No. 3050.005

Boring Co. Omaha Testing Division - P.S.I. Foreman: Scott Kratz OBG Geologist: Peter Bogardus	Boring Location: MW 6s, 6d Ground Elevation: Dates: Started: 11/3/85 Ended: 11/6/85

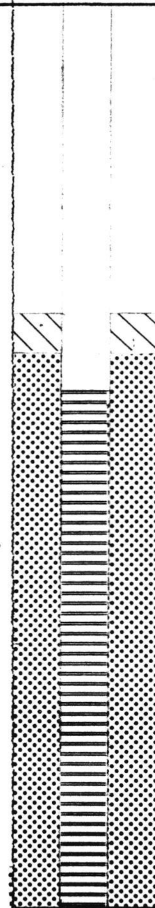
Depth	Sample #	Sample Penetrn/ Recovery	Sample Depth	Sample Blows /6"	Sample Description	Stratum Change General Descript	Equipment Installed		HNU	Rmks*
0'	1		0-1.5	6-6-7	Gray, moist, SILT, some fine Sand, trace Clay, organics					
					3'					
5'	2		5-6.5	3-3-5	Gray-green, moist, SILT, some Clay, trace fine Sand, (iron oxide stains)					
					9'					
10'	3		10-11.5	1-2-2	Gray-green, wet, FINE SAND, little Clay					
					15'					
15'	4		15-16.5	2-3-3	Gray, wet, SILT, some Fine to Medium SAND					
					15.5'					
20'	5		20-21.5	7-12-15	20.5'					
					Gray, wet, FINE to COARSE SAND					
25'	6		25-26.5	6-7-11						
					25.5'					
30'	7		30-31.5	4-8-9	Gray-black, moist CLAY, some Silt, trace coarse Sand					



O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. MW 7 Sheet 1 of 1
Project Location Maryville, Missouri Client: Nixdorff-Lloyd Chain Company	SAMPLER Type: Hammer: Fall:	Ground Water Depth Date Depth - Date - File No. 3050.005

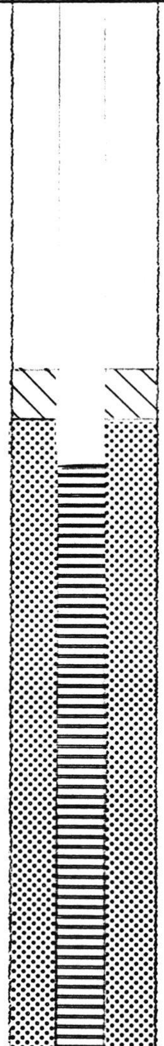
Boring Co. Omaha Testing Division - P.S.I. Foreman: Scott Kratz OBG Geologist: Peter Bogardus	Boring Location: MW 7 Ground Elevation: Dates: Started: 11/6/85 Ended: 11/7/85

Depth	Sample #	Sample Penetrn/ Recovery	Sample Depth	Sample Blows /6"	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0'	1		0-1.5	4-4-5	Gray, moist, SILT, some fine Sand, trace Clay, organics 2'						
6'	2		5-6.5	2-3-5	Orange, moist, SILT, some Clay, trace fine Sand. (iron oxide stains) 5.5'						
12'	3		10-11.5	2-2-3	Gray-green, moist, SILT, some Clay, trace fine to coarse Sand. (iron oxide stains) 11' Red-brown, moist, SILT, some Clay, trace fine to coarse Sand. (iron oxide stains) 13'						
18'	4		15-16.5	6-10-10	Gray, wet, FINE SAND, (silt lenses) 16'						
24'	5		20-21.5	8-10-10	Gray, wet, FINE to MEDIUM SAND 23'						
30'	6		25-26.5	9-11-5	Gray, wet, FINE to COARSE SAND, some fine to coarse Gravel, trace Clay 26'						
36'	7		30-31.5	SHELBY	Gray-black, moist, CLAY, little Silt, trace coarse Sand						
42'	8		40-41.5	SHELBY NO. REC							
48'	9 10		45-46.5 46.5-47	SHELBY SHELBY							



O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. MW 8 Sheet 1 of 1
Project Location Maryville, Missouri Client: Nixdorff-Lloyd Chain Company	SAMPLER Type: Hammer: Fall:	Ground Water Depth Date Depth - Date - File No. 3050.005

Boring Co. Omaha Testing Division - P.S.I. Foreman: Scott Kratz OBG Geologist: Peter Bogardus	Boring Location: MW 8 Ground Elevation: Dates: Started: 11/7/85 Ended: 11/7/85

Depth	Sample #	Sample Penetrn/ Recovery	Sample Depth	Sample Blows /6"	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0'	1		0-1.5	3-5-6	Gray, moist SILT, some fine Sand, trace Clay, organics. 3'						
5'	2		5-6.5	3-4-3	Gray-green, moist, SILT, some Clay, trace fine Sand. (iron oxide stains)						
10'	3		10-11.5	2-2-2	11' Gray, wet, SILT, some CLAY 13'						
15'	4		15-16.5	3-4-5	Gray-green, moist, SILT, some Clay, trace fine Sand. (iron oxide stains)						
20'	5		20-21.5	4-3-8	21' Gray, wet, FINE SAND, some Clay, trace Silt						
25'	6		25-26.5	11-11-15	26' Gray, wet, FINE to COARSE SAND, little fine Gravel. 27.5'						
30'	7		30-31.5	5-6-9	Gray-black, moist Clay, some Silt, trace coarse Sand.						
35'	8		35-36.5	SHELBY	- BOB 36.5						

INVOICE

Layne-Western Company, Inc.

WATER SUPPLY SERVICES

WATER WELLS • LAYNE PUMPS • TEST DRILLING • WATER TREATMENT EQUIPMENT

1010 West 39th Street • Kansas City, Missouri 64111 • AC 816 931-2353

Sold To Lloyd Chain Corp.,
Highway 136
Maryville, Missouri

Attn: Mr. Norman Craig

Date 4-22-70

CUST. ORDER

OUR ORDER KC 633-B

OUR INV. NO. 4518

TERMS: NET cash DAYS SHIPPED VIA F.O.B.

For test drilling and installation of 2 water supply wells at plant on Highway 136, Maryville, Missouri	
203 lineal feet of test boring @ 2.75 per ft...	$ 558.25
2 - 6" x 15" gravel wall wells @ 975.00 ea. ...	1,950.00
	$ 2,508.25

1% Interest Per Month Charged From 30 Days After Date of Invoice

TEST HOLE REPORT

Layne-Western Company

Contract Name Lloyd Chain Corporation

Job No. KC 633-B Date 4/6/70

City Maryville State Missouri

TEST HOLE No. 1-70

Driller J. Harper

Test Hole Location 15' E. 5' S. of S.E. corner of Building

Distance and Direction from Permanent Landmark or Previous Test Hole

TEST LOG

Static Water Level ______ Measured ______ Hours After Completion

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	FORMATION
0'0"	1'0"			Brown clay fill
1'0"	5'0"			Dark gray clay, stiff
5'0"	11'0"			Gray clay, stiff
11'0"	20'0"			Dark brown clayey silt, soft
20'0"	22'0"			Gray sandy clay, soft
22'0"	25'0"	water	2"	Gray med. to coarse, some fine sand
25'0"	30'6"	"	5"	Gray med. to coarse, tr. fine sand, gravel
30'6"	80'0"			Gray sandy clay, few boulders, stiff
80'0"	Total depth			

NOTES: Size of Pit 5'0" X 3'6" X 4'0" DEEP

25 GPM
83 PSI Gage

WELL INFORMATION

Layne-Western Co. Inc.

1. CONTRACT LLOYD CHAIN CORP.
2. City, State MARYVILLE, MISSOURI
3. Well No. 2 No. at Test Hole No. 3
4. Well Location (attach map) 225' NORTH OF WELL NO. 1 & 15'0" EAST OF BUILDING LINE
5. Driller O. J. HARPER
6. DATE 4-10-70
7. Date Started 4-8-70
   Completed 4-9-70
8. Drill Crew Man Hrs.
9. Working Days
   Drilling
   Other

10. MATERIAL IN WELL

	LENGTH FT. IN.	DIA. IN.	GAGE NO.	WALL THICK-NESS IN.	MATERIAL	TYPE	NO.
Screen	5' 0"	6"	—	—	STEEL	SHUTTER (Shutter / ~~Keystone~~)	7 Openings
Inner Casing	23' 6"	6"	—	—	STEEL	SCREWED (~~Welded~~ / Screwed)	
Outer Casing	— —	N	O	N E		Welded / Screwed	

11. GRAVEL

Size #3 & #4 GRAVEL

Tons 2½ plus 1 ton concrete sand

12. SEALING CASING

Puddled Clay (Yes) (No)

With 4 Bags Bentonite Added

or

With .... Bags Cement

Seal Material Placed in Well With SHOVEL

Bottom of Well Screen Sealed With WASH PLUG

13. WELL DIMENSIONS

A. Total Depth 28' 6"
(From Top of Inner Casing to Bottom of Well)

B. Height of Inner Casing 1'0"
(Above Ground Level)

C. Distance to Top of Gravel 14'0"
(From Ground Level)

D. Diameter of Drill Hole 18"

Comments

LW-39

35 GPM

@ 3 PSI GAGE

WELL INFORMATION

Layne-Western Co. Inc.

1. CONTRACT LLOYD CHAIN CORP.
2. City, State MARYVILLE, MISSOURI
3. Well No. 1 SO. at Test Hole No. 1-70
4. Well Location (attach map) 15' EAST & 5' SOUTH OF S.E. CORNER OF BUILDING
5. Driller O. J. HARPER
6. DATE 4-10-70
7. Date Started 4-8-70
   Completed 4-9-70
8. Drill Crew Man Hrs.
9. Working Days
   Drilling
   Other

10. MATERIAL IN WELL

	LENGTH FT. IN.	DIA. IN.	GAGE NO.	WALL THICKNESS IN.	MATERIAL	TYPE	NO.
Screen	5' 0"	6"	—	—	STEEL	SHUTTER (Shutter ~~Keystone~~)	7 Openings
Inner Casing	26' 6"	6"	—	—	STEEL	SCREWED (~~Welded~~ Screwed)	
Outer Casing	— —	N	O	NE		Welded Screwed	

11. GRAVEL

Size #3 & #4 GRAVEL plus 3/4 ton Concrete sand

Tons 3

12. SEALING CASING

Puddled Clay (Yes) (No)

With 4 Bags Bentonite Added

or

With .... Bags Cement

Seal Material Placed in Well With SHOVEL

Bottom of Well Screen Sealed With WASH PLUG

13. WELL DIMENSIONS

A. Total Depth 31' 6" (From Top of Inner Casing to Bottom of Well)

B. Height of Inner Casing 1' 0" (Above Ground Level)

C. Distance to Top of Gravel 14' 0" (From Ground Level)

D. Diameter of Drill Hole 18"

Comments

LW-39

PUMPING TEST

A. Test pump ....in................Bowl................Stages

Permanent pu

Length of column ....Ft.

Length of Bowl ....Ft.

Length of suction ....Ft.

B. Measured water level .... Ft. from top of ....In. dia. casing which is .... Ft. above ground.

C. Length of airline ....Ft. from top of casing.

ORIFICE

..........................x..........................

..........................x..........................

TIME	INCHES ORIFICE MANOMETER	GPM	ALT. GAGE READING	WATER LEVEL	DRAW DOWN
2:50 pm		0		7.2'	0
2:51		75		19.0'	
2:52		75		20.8'	
:53		75		21.8'	
2:54		75		21.9'	
2:55		75		23.5'	
3:00		60		24.5'	
3:15		50		24.2'	
3:30		50		24.7'	
4:00		50		25.6'	
5:00		50		25.9'	

RECOVERY FROM 25.9' TO 15.2' BY 5:30 (30 minutes)

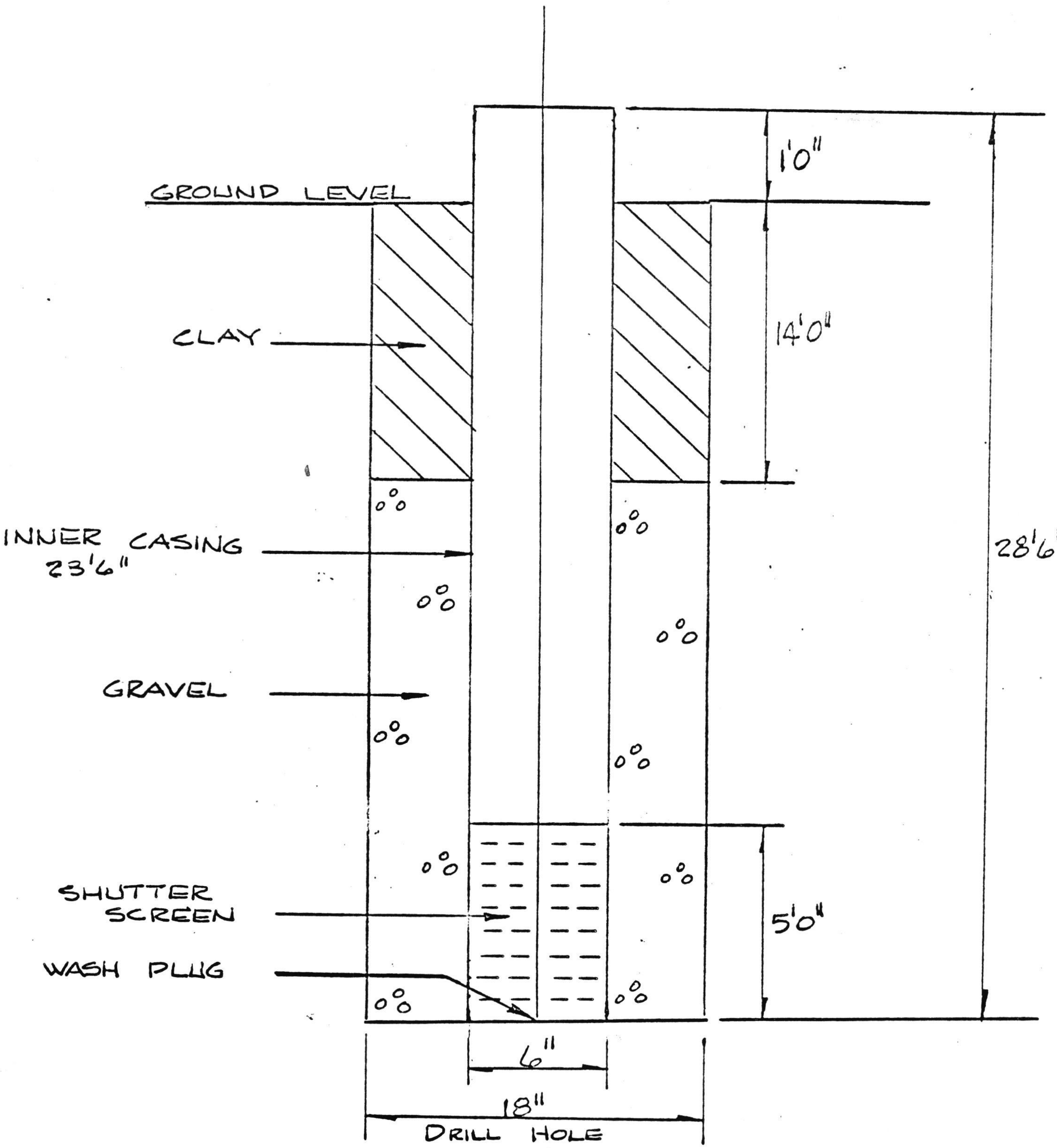
1 Permanent .... Pump No. .... installed by ....

Layne

Permanent air line length ....Ft. Date..............................

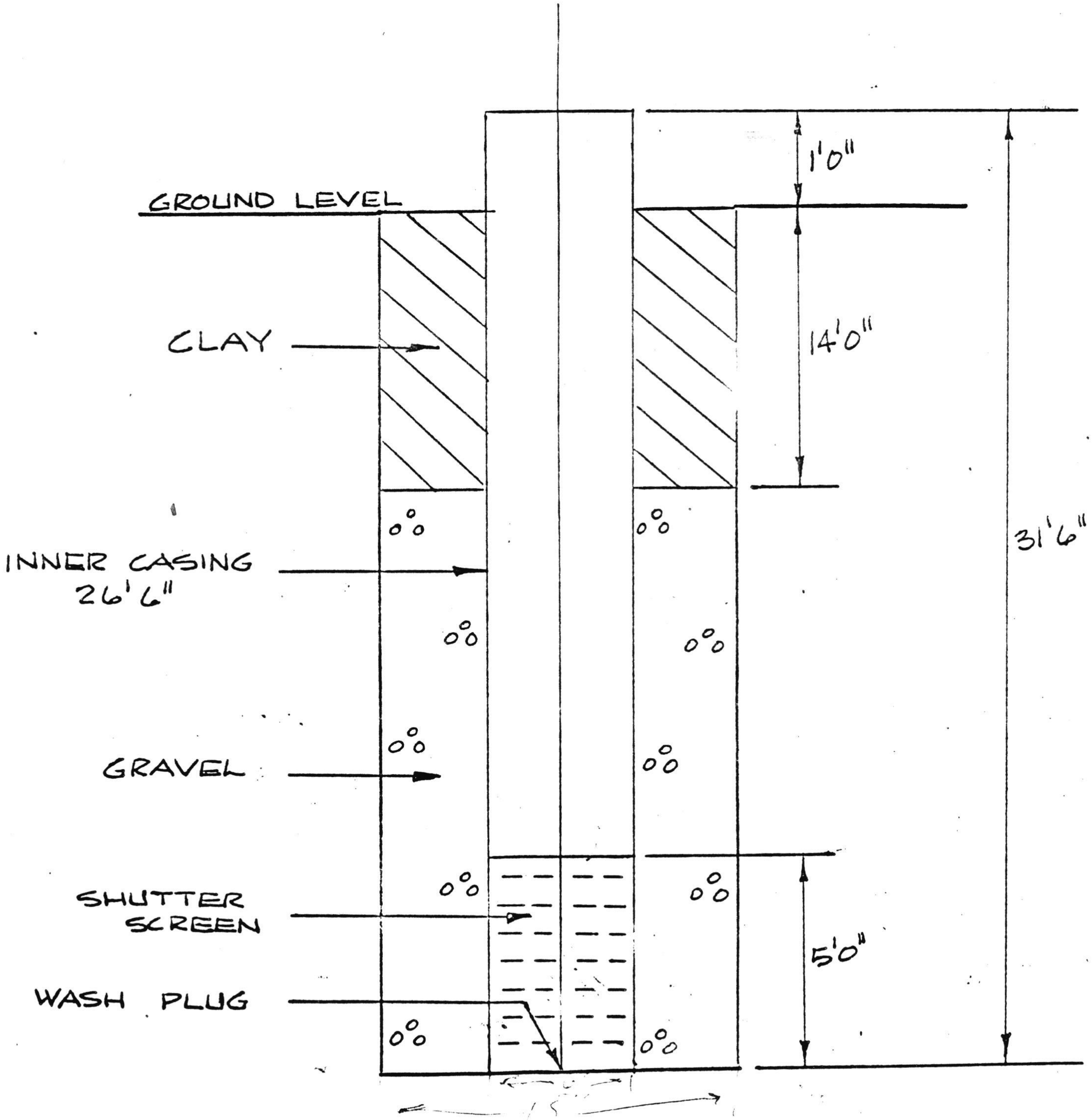
Month Day Year

CONSTRUCTION OF WELL



PUMP 29½ FEET FROM GROUND LEVEL

CONSTRUCTION OF WELL



11. PUMPING TEST

A.

Test pump
..................in..................Bowl..................Stages
Permanent pump

Length of column ....Ft.

Length of Bowl ....Ft.

Length of suction ....Ft.

B. Measured water level .... Ft. from top of ....In. dia. casing which is .... Ft. above ground.

C. Length of airline ....Ft. from top of casing.

ORIFICE

..............................x..............................

..............................x..............................

TIME	INCHES ORIFICE MANOMETER	GPM	ALT. GAGE READING	WATER LEVEL	DRAW DOWN
9:00 am		0 42.0		4.8'	0
9:01		43.0		11.3'	
9:02		43.0		12.5'	
:03		43.0		13.6'	
9:04		43.0		14.4'	
9:05		43.0		15.0'	
9:10		43.0		17.0'	
9:15		43.0		18.0'	
9:30		43.0		20.1'	
10:00		43.0		21.7'	
1:45 pm		43.0		23.1'	

RECOVERY FROM 23.1' TO 9.4' BY 2:15 pm (30 minutes)

15. Permanent .... Pump No. .... installed by ....
Layne

Permanent air line length ....Ft. Date..............................
Month Day Year

APPENDIX C

In Situ Hydraulic Conductivity Test Data

O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

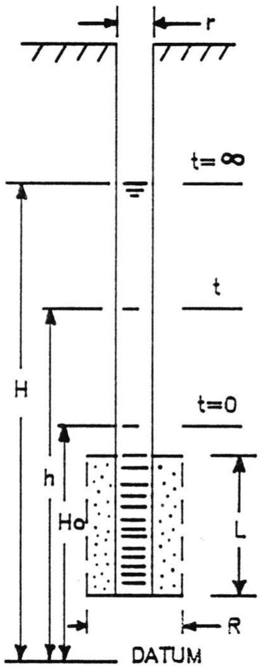
PROJECT NLCC

WELL NUMBER MW25

DATE 11/14/85

LOCATION

ELEVATION



STATIC HEAD (H) 14.0'

PIPE RADIUS (r) .167

SCREEN RADIUS (R) .33

SCREEN LENGTH (L) 10

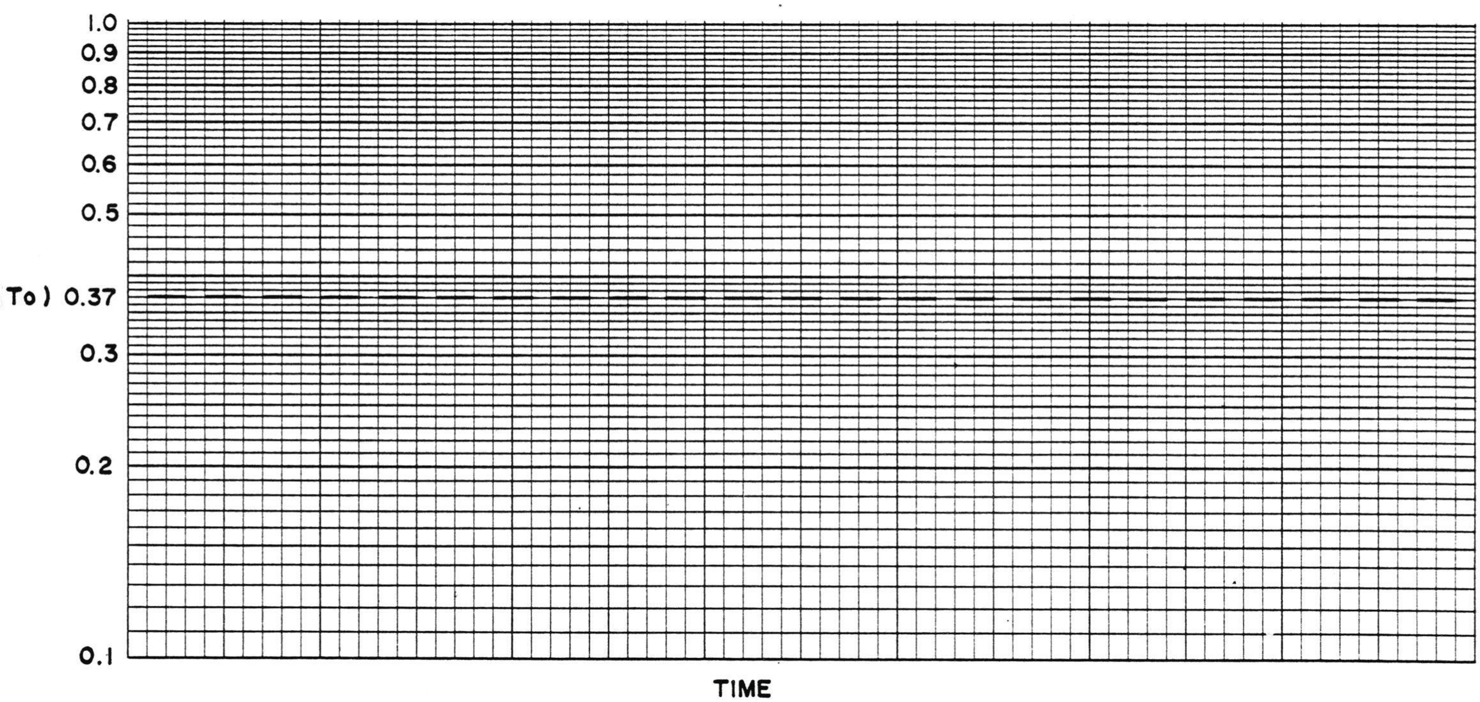
INITIAL HEAD (Ho) 10.5'

HYDRAULIC CONDUCTIVITY :

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K= 2.4 x 10^{-4} cm/sec
7.9 x 10^{-6} ft/sec

(MIN) TIME	WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
0	11.33	0	10.50	1
.58	10.92	.58	10.91	.88
.91	10.71	.91	11.13	.78
2	10.54	2	11.29	.77
2.23	10.33	2.23	11.50	.72
3.06	10.17	3.06	11.67	.67
4	10.00	4	11.83	.62
4.8	9.92	4.8	11.92	.60
6.83	9.71	6.83	12.13	.57
8.5	9.38	8.5	12.45	.45
10.0	9.13	10.0	12:71	.37
11.5	9.0	11.5	12.83	.33
15	8.88	15	12.96	.30
19	8.5	19	13.33	.20

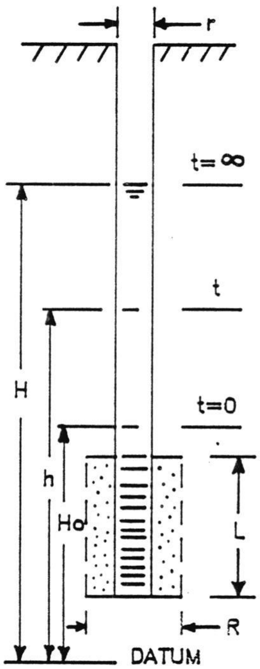


O'BRIEN & GERE

IN–SITU PERMEABILITY TEST
FIELD LOG

PROJECT NLCC
WELL NUMBER MW2D
DATE 11/14/85

LOCATION
ELEVATION



STATIC HEAD (H) 28.54

PIPE RADIUS (r) .083

SCREEN RADIUS (R) .083

SCREEN LENGTH (L) 5

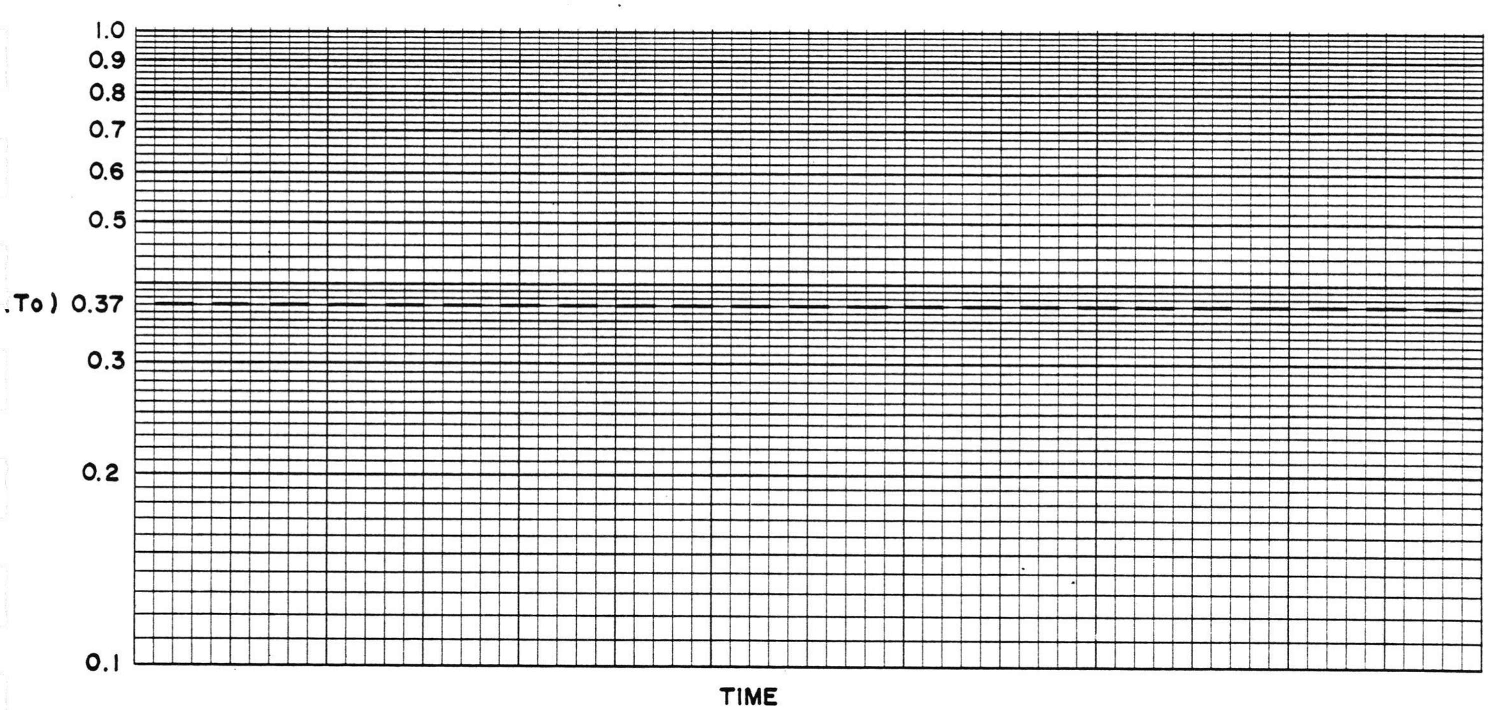
INITIAL HEAD (Ho) 25

HYDRAULIC CONDUCTIVITY :

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

$K = \frac{4.3 \times 10^{-4}\ cm/sec}{1.4 \times 10^{-5}\ ft/sec}$

(MIN) TIME	WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
0	10	0	25	1
.31	9.5	.31	25.5	.86
.5	9.25	.5	25.75	.79
.83	9.0	.83	26.0	.72
1.08	8.87	1.08	26.13	.68
1.33	8.62	1.33	26.38	.61
1.51	8.5	1.51	26.50	.57
1.91	8.38	1.91	26.62	.54
2.16	8.16	2.16	26.84	.48
3.20	7.83	3.20	27.17	.39
3.65	7.66	3.65	27.34	.34
4.50	7.50	4.50	27.50	.29
5.25	7.33	5.25	27.67	.24
6.50	7.17	6.50	27.83	.20
8.00	7.04	8.00	27.96	.16
10.0	6.88	10.00	28.12	.12



O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

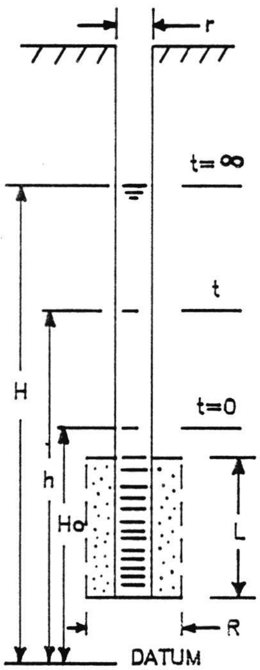
PROJECT NLCC

WELL NUMBER MW 3

DATE 11/14/85

LOCATION MARYVILLE, MO.

ELEVATION



STATIC HEAD (H) 14.96

PIPE RADIUS (r) .166

SCREEN RADIUS (R) .33

SCREEN LENGTH (L) 10

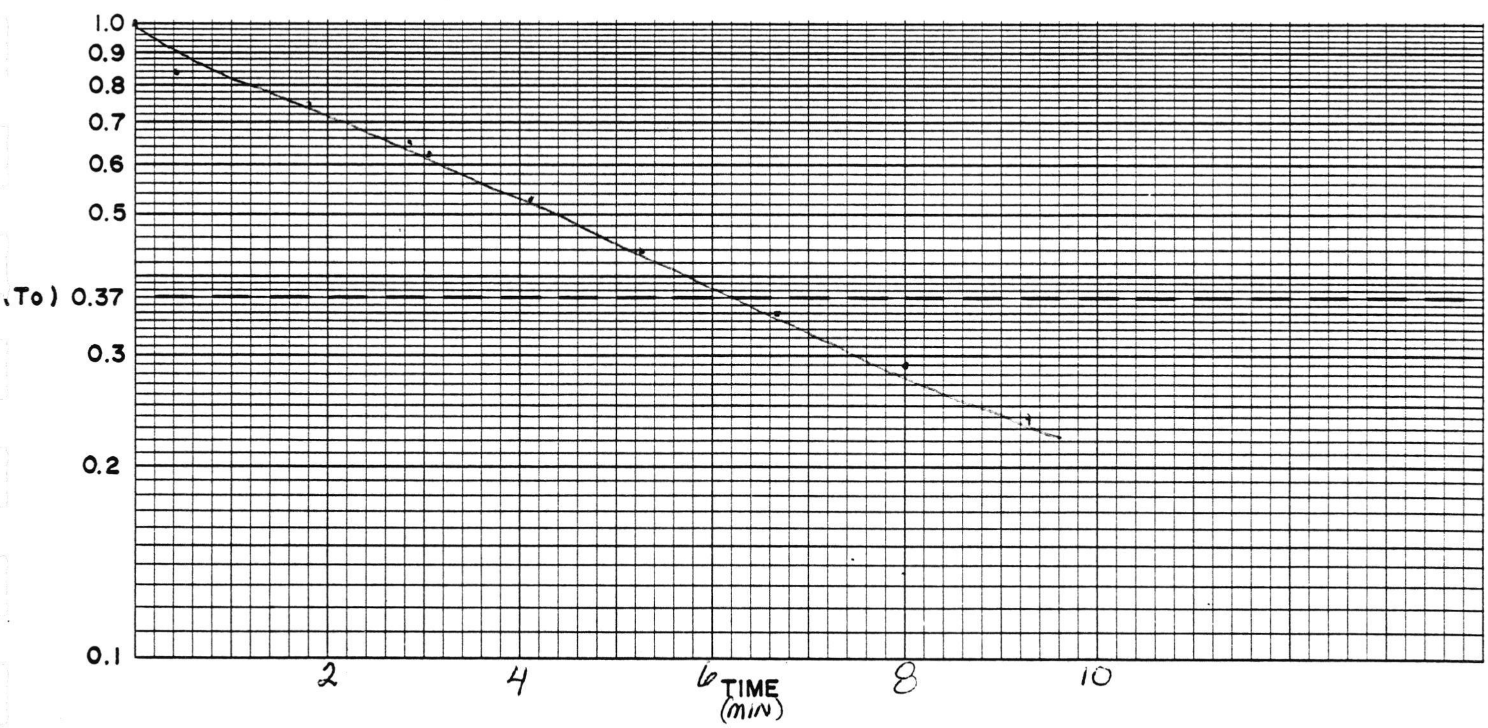
INITIAL HEAD (Ho) 1.5

HYDRAULIC CONDUCTIVITY :

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K= $\dfrac{3.7 \times 10^{-4} \text{ cm/sec}}{1.2 \times 10^{-5} \text{ ft/sec}}$

TIME	WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
0	17.16	0	1.5	1
.43	15	.43	3.66	.84
1.78	13.83	1.78	4.83	.75
2.87	12.5	2.87	6.16	.65
3.15	12.0	3.15	6.66	.62
4.15	10.9	4.15	7.75	.53
5.28	9.75	5.28	8.91	.44
6.68	8.58	6.68	10.08	.35
8.0	7.75	8.00	10.91	.29
9.33	7.0	9.33	11.66	.24

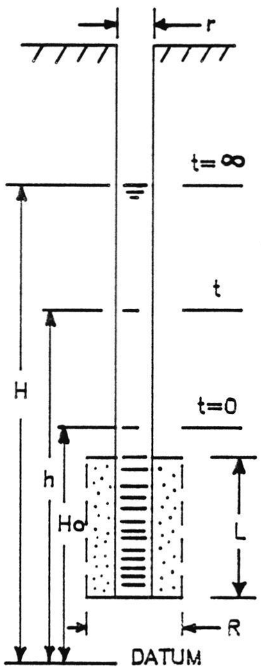


O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

PROJECT NLCC
WELL NUMBER MW 4S
DATE 11/14/85

LOCATION MARYVILLE, MO
ELEVATION ______



STATIC HEAD (H) 19.67

PIPE RADIUS (r) .166

SCREEN RADIUS (R) .33

SCREEN LENGTH (L) 10

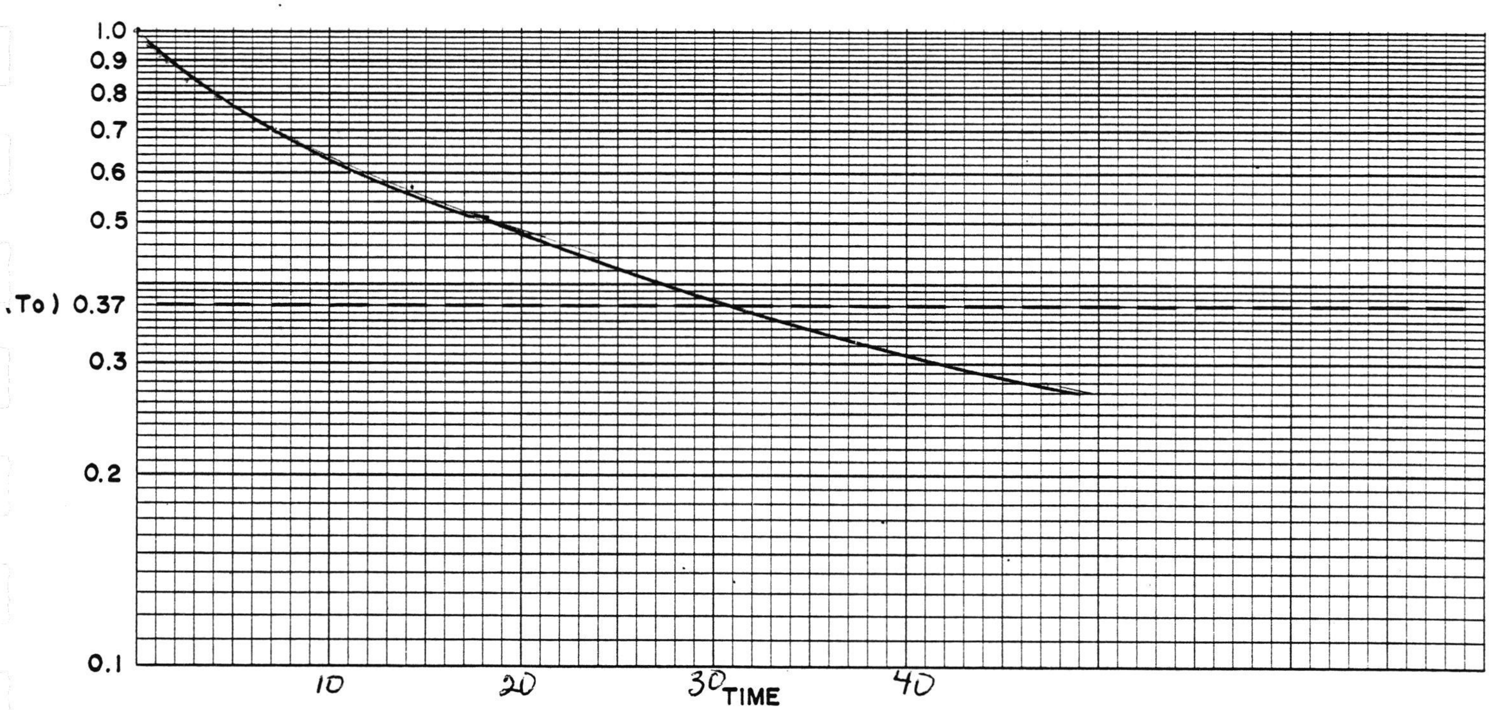
INITIAL HEAD (Ho) 7.67

HYDRAULIC CONDUCTIVITY :

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K = $\frac{8.2 \times 10^{-5} \text{ cm/sec}}{2.7 \times 10^{-6} \text{ ft/sec}}$

(min) TIME	WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
0	17.33	0	7.67	1
.5	16.75	.5	8.25	.95
.78	16.58	.78	8.42	.93
1.16	16.33	1.16	8.67	.91
1.56	16.00	1.56	9.00	.89
3.62	15.41	3.62	9.59	.84
4.18	14.75	4.18	10.25	.79
7.10	13.75	7.10	11.25	.70
9.66	13.08	9.66	11.92	.64
14.16	12.17	14.16	12.83	.57
20.00	11.17	20.00	13.83	.48
47.08	8.75	47.08	16.25	.28



O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

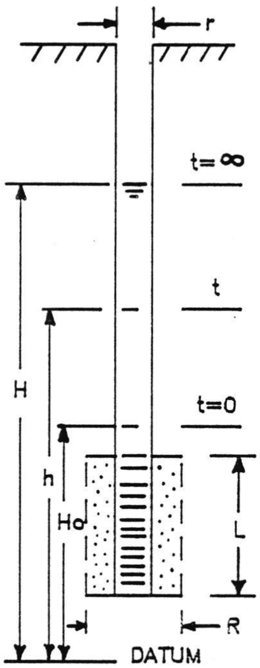
PROJECT NLCC

WELL NUMBER MW 40

DATE 11/14/85

LOCATION MARYVILLE, MO.

ELEVATION ______



STATIC HEAD (H) 28.29'

PIPE RADIUS (r) .083'

SCREEN RADIUS (R) .083'

SCREEN LENGTH (L) 5'

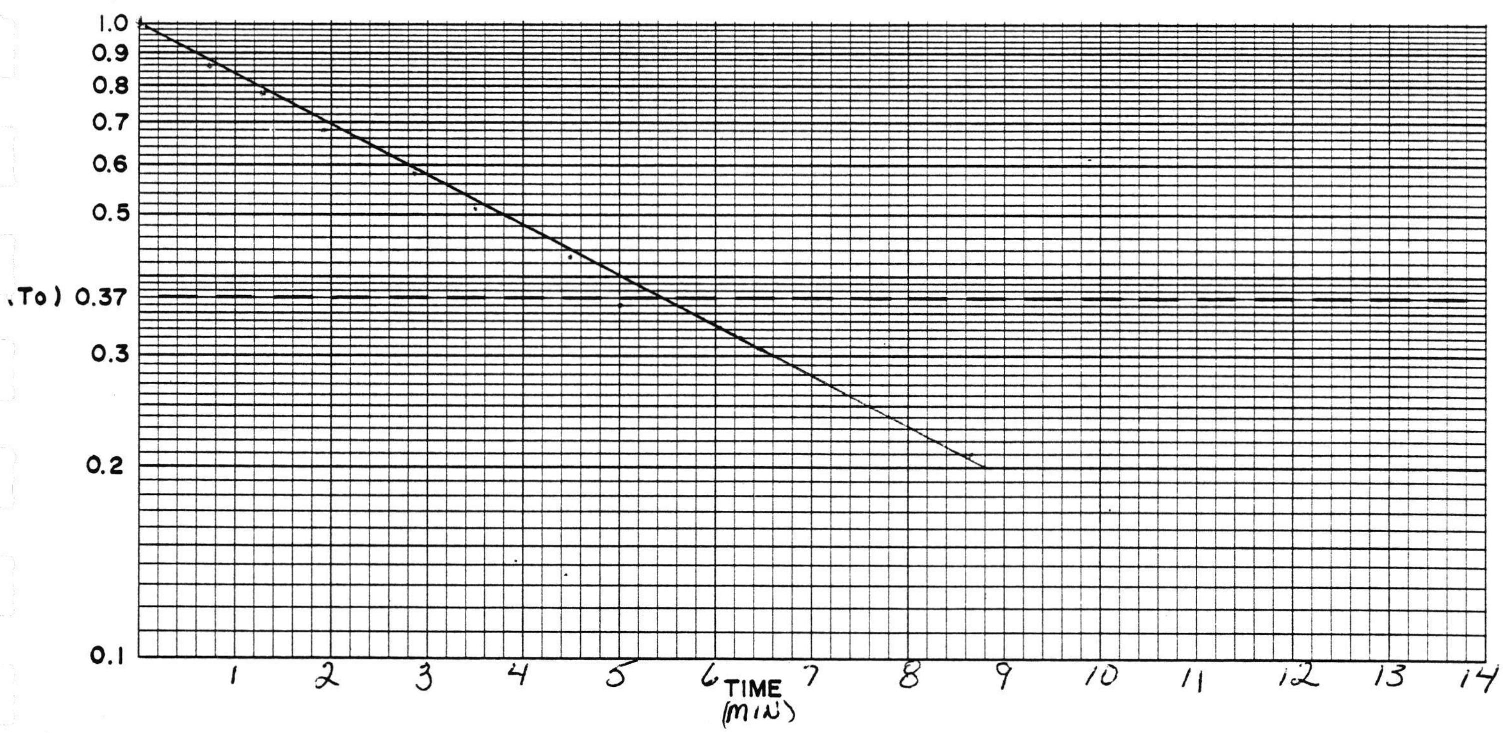
INITIAL HEAD (Ho) 20.59'

HYDRAULIC CONDUCTIVITY :

$$K=\frac{r^2 \ln(L/R)}{2LTo}$$

K= 2.6×10^{-4} cm/sec
8.7×10^{-6} ft/sec

(min) TIME	WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
0	14.41	0	20.59	1
.73	13.38	.73	21.62	.86
1.30	12.75	1.30	22.25	.78
1.93	12.08	1.93	22.92	.69
2.83	11.21	2.83	23.79	.58
3.50	10.62	3.50	24.38	.51
4.50	10.00	4.50	25.00	.43
5.00	9.51	5.00	25.49	.36
6.25	9.17	6.25	25.83	.32
8.65	8.33	8.65	26.67	.21
15.00	7.25	15.00	27.75	.07



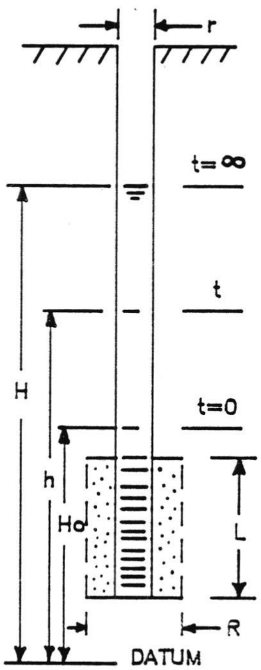
O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

PROJECT N.L.C.C LOCATION [illegible]

WELL NUMBER mw 5S ELEVATION

DATE 11/1/85



STATIC HEAD (H) 14.4'

PIPE RADIUS (r) .083

SCREEN RADIUS (R) .25

SCREEN LENGTH (L) 10

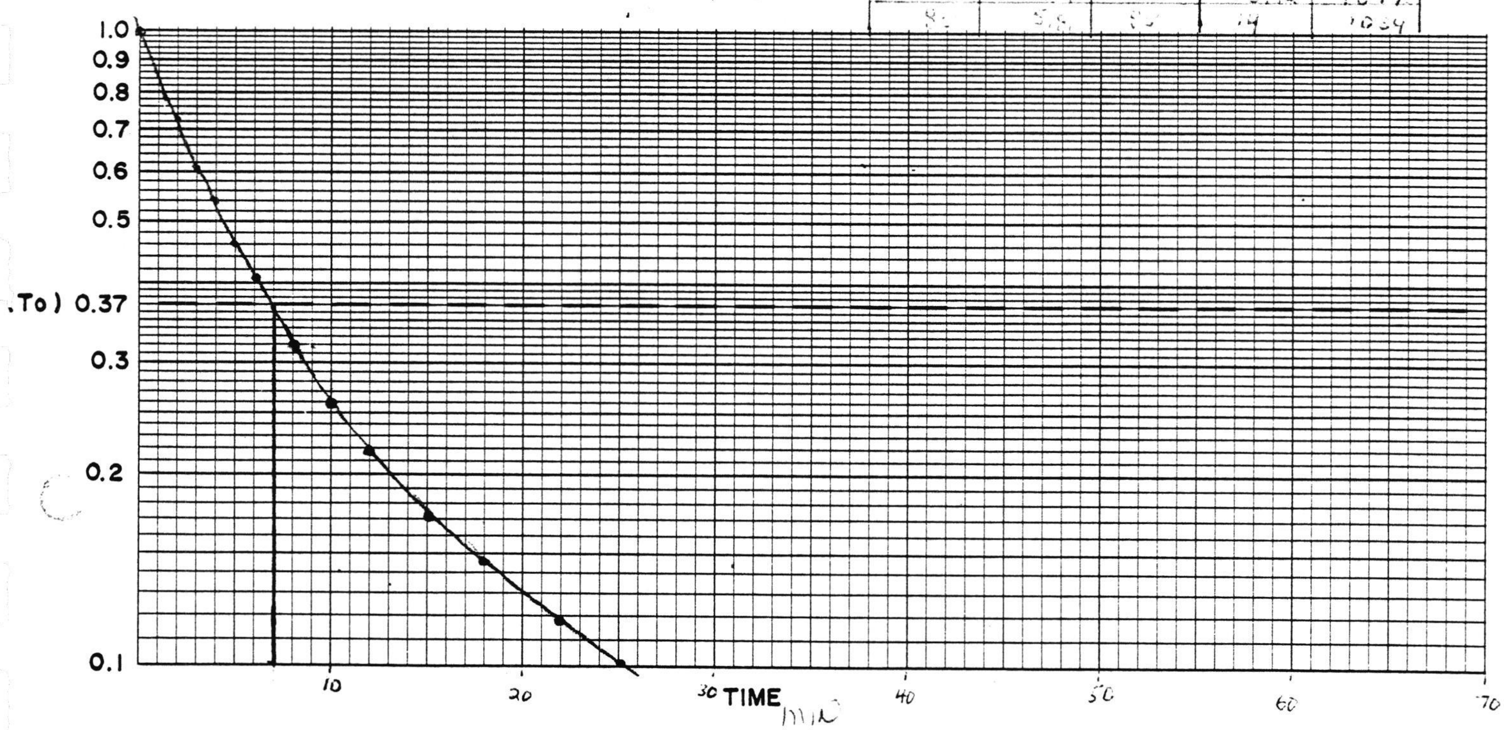
INITIAL HEAD (Ho) 4.2

HYDRAULIC CONDUCTIVITY :

$$K=\frac{r^2 \ln(L/R)}{2LT_o}$$

K= 9.2 x10⁻⁵ cm/sec

TIME	WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
0	15.6[illegible]	0	4.2	1
1.5	13.46	1.5	6.35	.79
2	[illegible]	2	6.95	.73
3	[illegible]	3	8.15	.61
4	[illegible]	4	8.6[illegible]	.54
5	[illegible]	5	9.05	.4[illegible]
6	[illegible]	6	10.2	.41
8	[illegible]	8	[illegible]	.32
10	[illegible]	10	[illegible]	.26
12	7.04	12	12.17	.219
15	7.[illegible]	15	12.62	.174
18	6.[illegible]	18	12.9	.147
22	6.63	22	13.18	.119
26	6.[illegible]	26	13.35	.102
30	6.[illegible]	30	13.45	.093
35	[illegible]	35	13.55	.0[illegible]
40	6.10	40	13.65	.075
45	6.13	45	13.62	.070
50	6.06	50	13.75	.063
60	5.91	60	13.9	.049
70	5.9[illegible]	70	13.92	.047
80	5.8	80	14	.034



O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

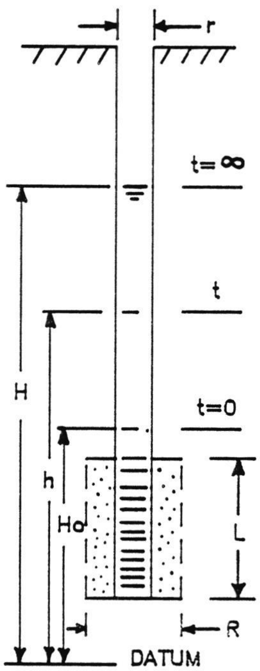
PROJECT NLCC

WELL NUMBER MW 5D

DATE 11/14/85

LOCATION MARYVILLE, MO

ELEVATION ______



STATIC HEAD (H) 31.7

PIPE RADIUS (r) .083

SCREEN RADIUS (R) .083

SCREEN LENGTH (L) 5

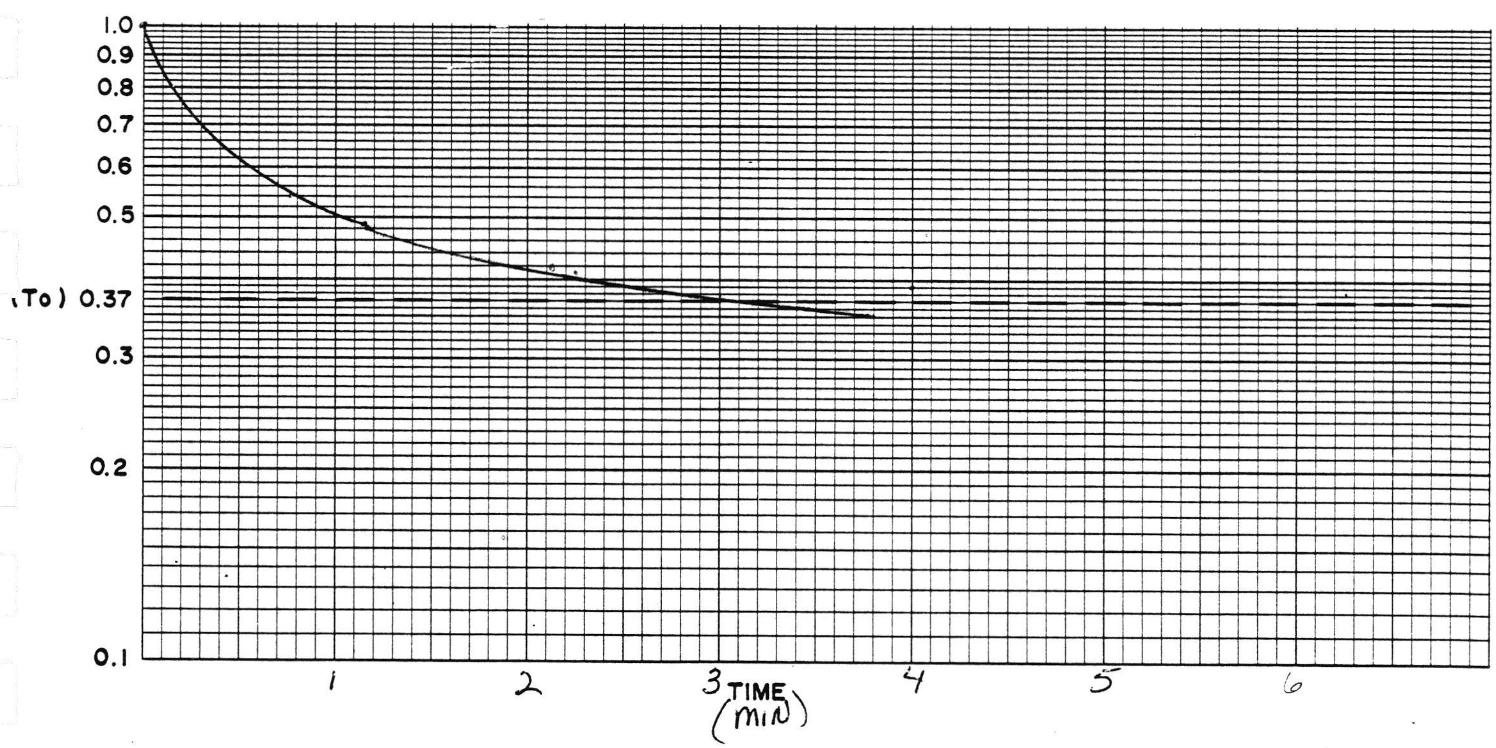
INITIAL HEAD (Ho) 28.58

HYDRAULIC CONDUCTIVITY :

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

$$K = \frac{4.5 \times 10^{-4}\ \text{cm/sec}}{1.5 \times 10^{-5}\ \text{ft/sec}}$$

(SEC) TIME	WATER DEPTH	(MIN) t	h	$\frac{H-h}{H-Ho}$
0	16.42	0	28.58	1
46	10.00	.76	30.00	.54
70	9.83	1.16	30.17	.49
128	9.62	2.13	30.38	.42
135	9.60	2.25	30.40	.41
240	9.54	4.00	30.46	.39
375	9.50	6.25	30.5	.38



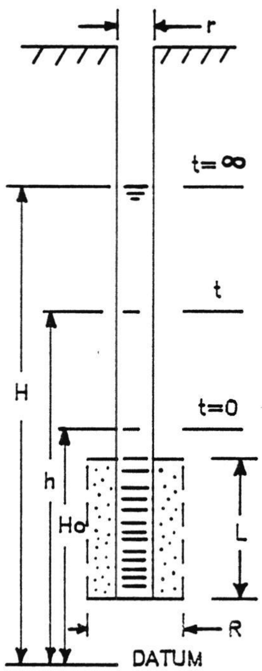
O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

PROJECT NLCC — LOCATION MARYVILLE, MO

WELL NUMBER MW 6S — ELEVATION ______

DATE 11/12/85



STATIC HEAD (H) 13.58'

PIPE RADIUS (r) .083'

SCREEN RADIUS (R) .083'

SCREEN LENGTH (L) 10'

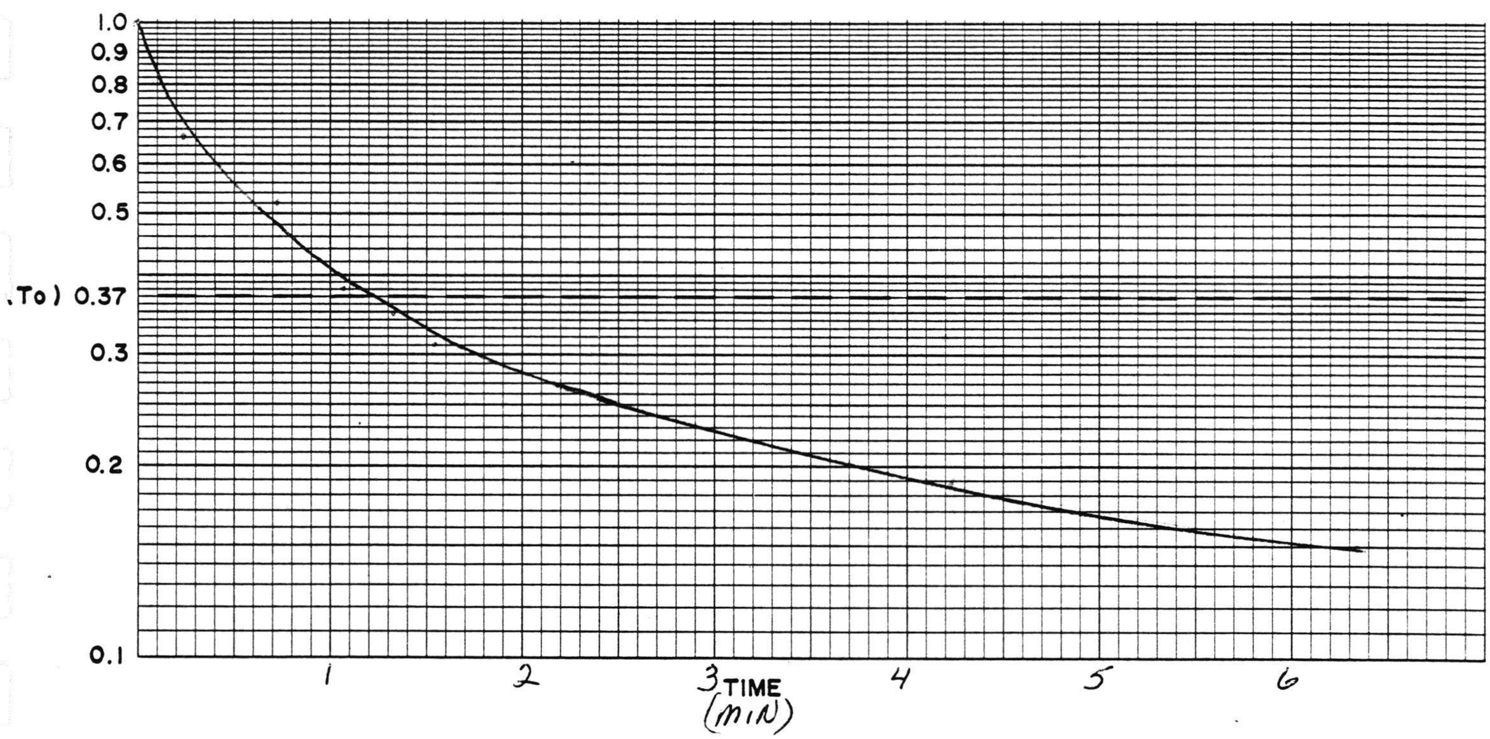
INITIAL HEAD (Ho) 11.18'

HYDRAULIC CONDUCTIVITY :

$$K = \frac{r^2 \ln(L/R)}{2L \cdot To}$$

K = 7.0 x 10^{-4} cm/sec / 2.3 x 10^{-5} ft/sec

(SEC) TIME	WATER DEPTH	(MIN) t	h	$\frac{H-h}{H-Ho}$
0	8.82	0	11.18	1
20	8.00	.33	12.00	0.66
43	7.66	.71	12.34	0.52
65	7.33	1.08	12.67	0.38
79	7.25	1.31	12.75	0.35
94	7.16	1.56	12.84	0.31
143	7.04	2.37	12.96	0.26
255	6.88	4.25	13.12	0.19
380	6.79	6.33	13.21	0.15

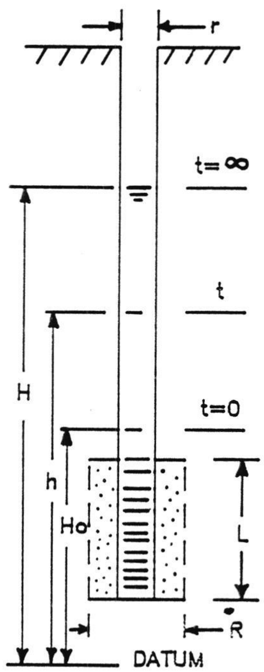


O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

PROJECT NLCC
WELL NUMBER MW 6D
DATE 11/12/85

LOCATION MARYVILLE, MO
ELEVATION



STATIC HEAD (H) 19.97'

PIPE RADIUS (r) .083'

SCREEN RADIUS (R) .083'

SCREEN LENGTH (L) 5'

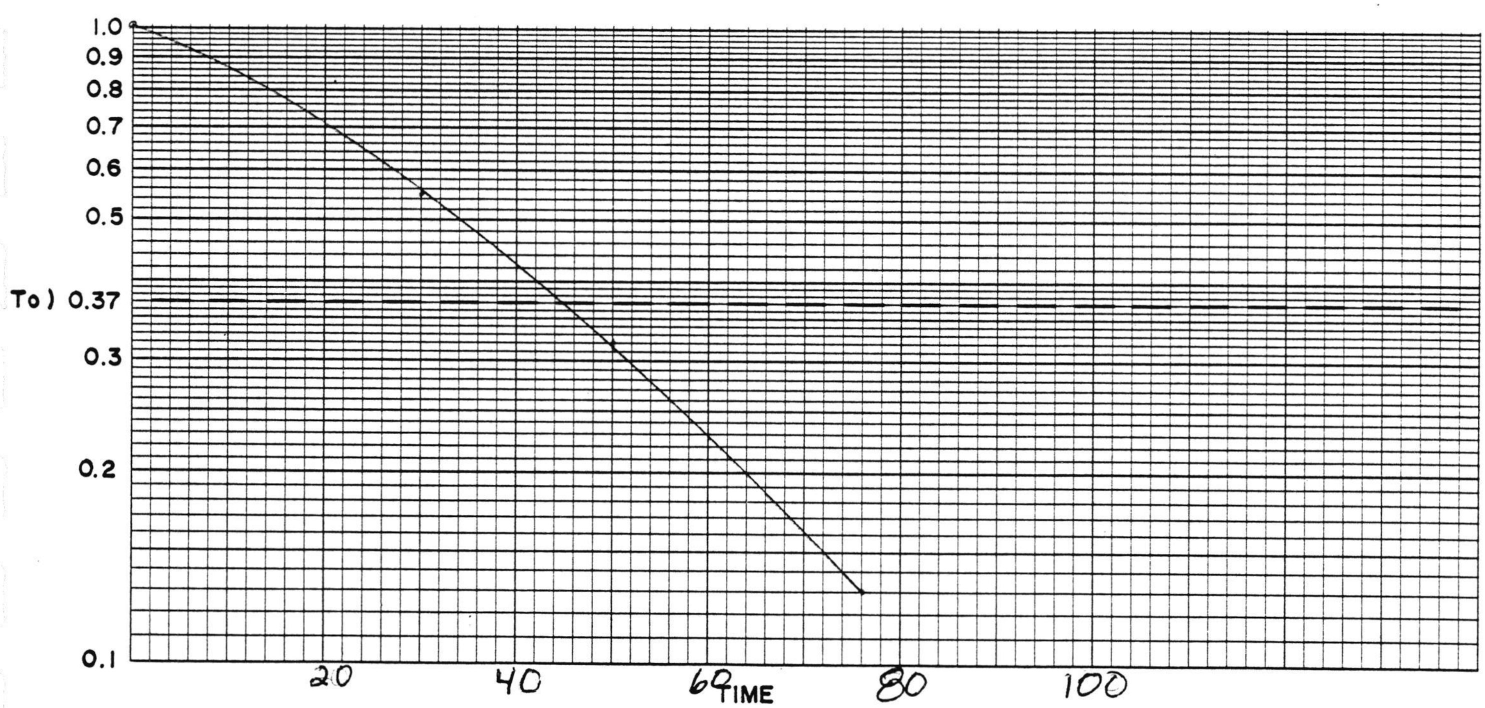
INITIAL HEAD (Ho) 16.8'

HYDRAULIC CONDUCTIVITY :

$$K=\frac{r^2\ln(L/R)}{2LT_o}$$

K= 2.0 x 10^-3 cm/sec
6.7 x 10^-5 ft/sec

(SEC) TIME	WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
0	10.50	0	16.80	1
30	9.08	30	18.22	.55
50	8.33	50	18.97	.32
78	7.75	78	19.55	.13
94	7.42	92	19.88	



O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

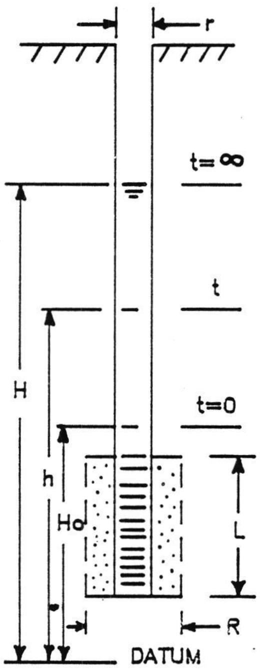
PROJECT NLCC

WELL NUMBER MW 7

DATE 11/13/85

LOCATION MARYVILLE, MO

ELEVATION ______



STATIC HEAD (H) 30'

PIPE RADIUS (r) .083'

SCREEN RADIUS (R) .083'

SCREEN LENGTH (L) 13'

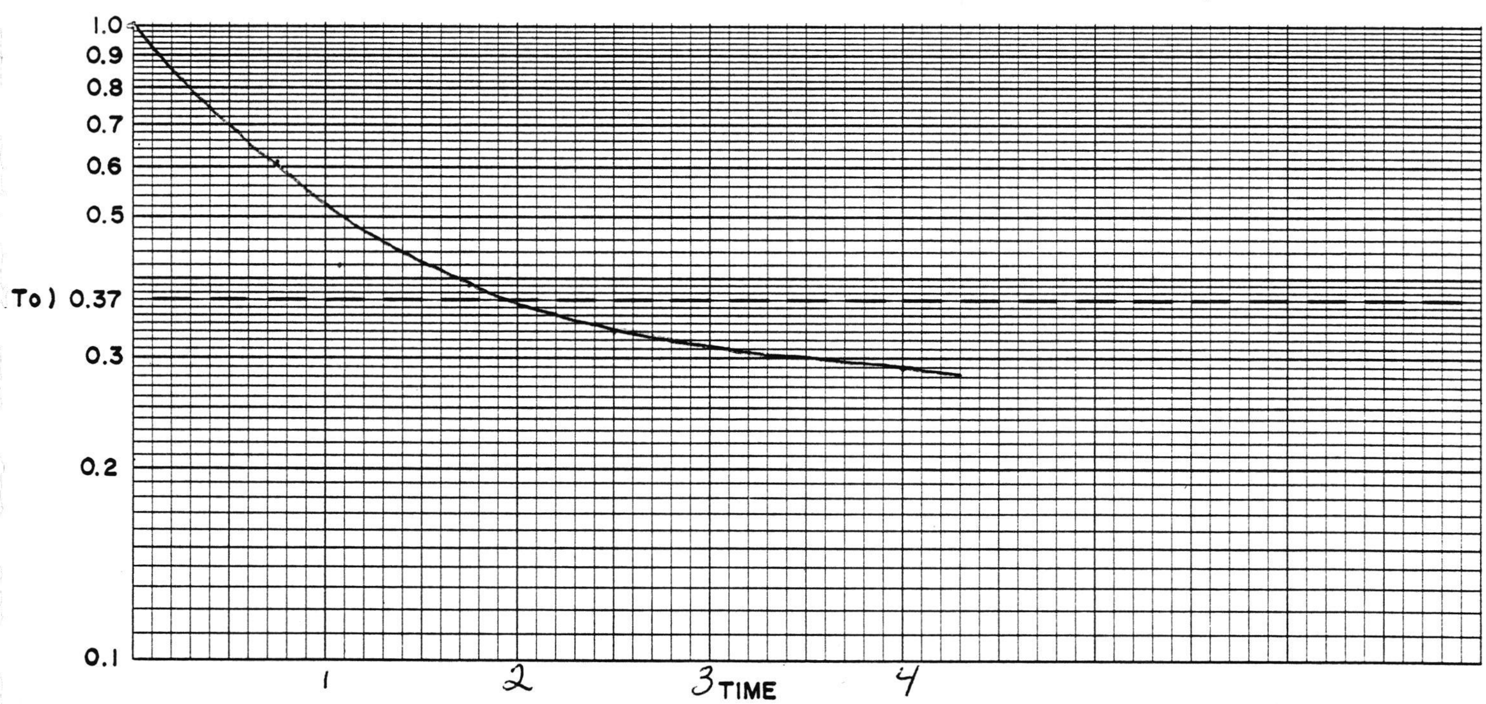
INITIAL HEAD (Ho) 20.7'

HYDRAULIC CONDUCTIVITY :

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K= 3.5×10^{-4} cm/sec / 1.2×10^{-5} ft/sec

(MIN) TIME	WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
0	14.3	0	20.7	1
.75	10.7	.75	24.3	.61
1.08	8.9	1.08	26.1	.42
1.75	8.6	1.75	26.4	.39
2.50	8.1	2.50	26.9	33
4.00	7.7	4.00	27.3	.29

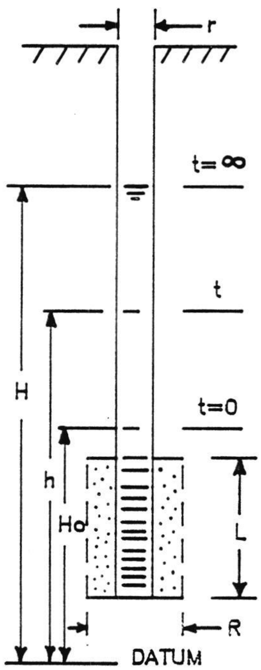


O'BRIEN & GERE

IN–SITU PERMEABILITY TEST
FIELD LOG

PROJECT NLCC
WELL NUMBER MW 8
DATE 11/13/85

LOCATION MARYVILLE, MO
ELEVATION ______

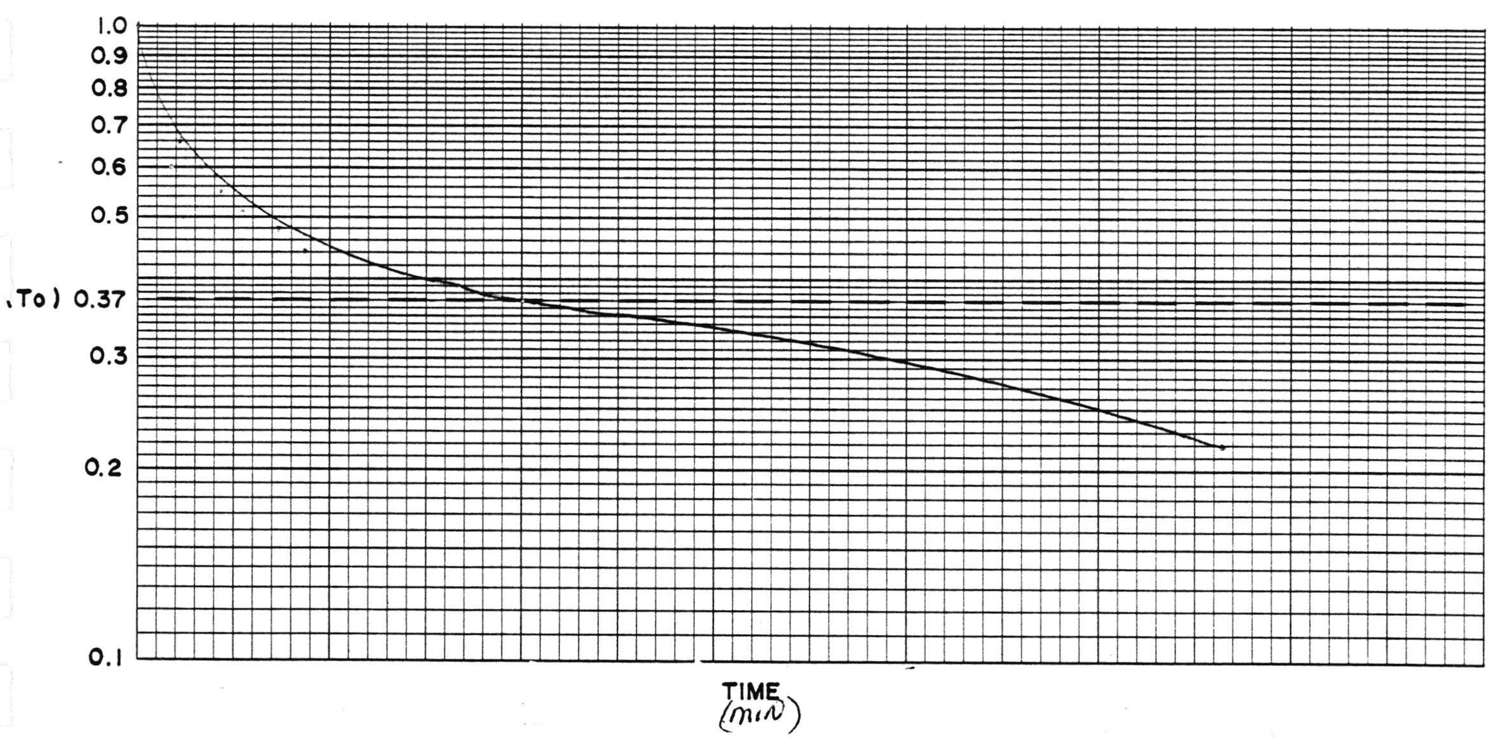


STATIC HEAD (H) 29.46'
PIPE RADIUS (r) .083
SCREEN RADIUS (R) .083
SCREEN LENGTH (L) 15'
INITIAL HEAD (Ho) 24.5'
HYDRAULIC CONDUCTIVITY :

$$K=\frac{r^2 \ln(L/R)}{2LT_o}$$

K= 3.0 x 10^-4 cm/sec
9.9 x 10^-6 ft/sec

(min) TIME	WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
0	10.5	0	24.5	1
.21	8.83	.21	26.17	.66
.32	8.50	.32	26.50	.60
.43	8.25	.43	26.75	.55
.55	8.08	.55	26.92	.51
.73	7.91	.73	27.09	.48
.88	7.75	.88	27.25	.44
1.55	7.54	1.55	27.46	.40
2	7.37	2	27.63	.37
2.96	7.25	2.96	27.75	.34
5.65	6.66	5.65	28.34	.22

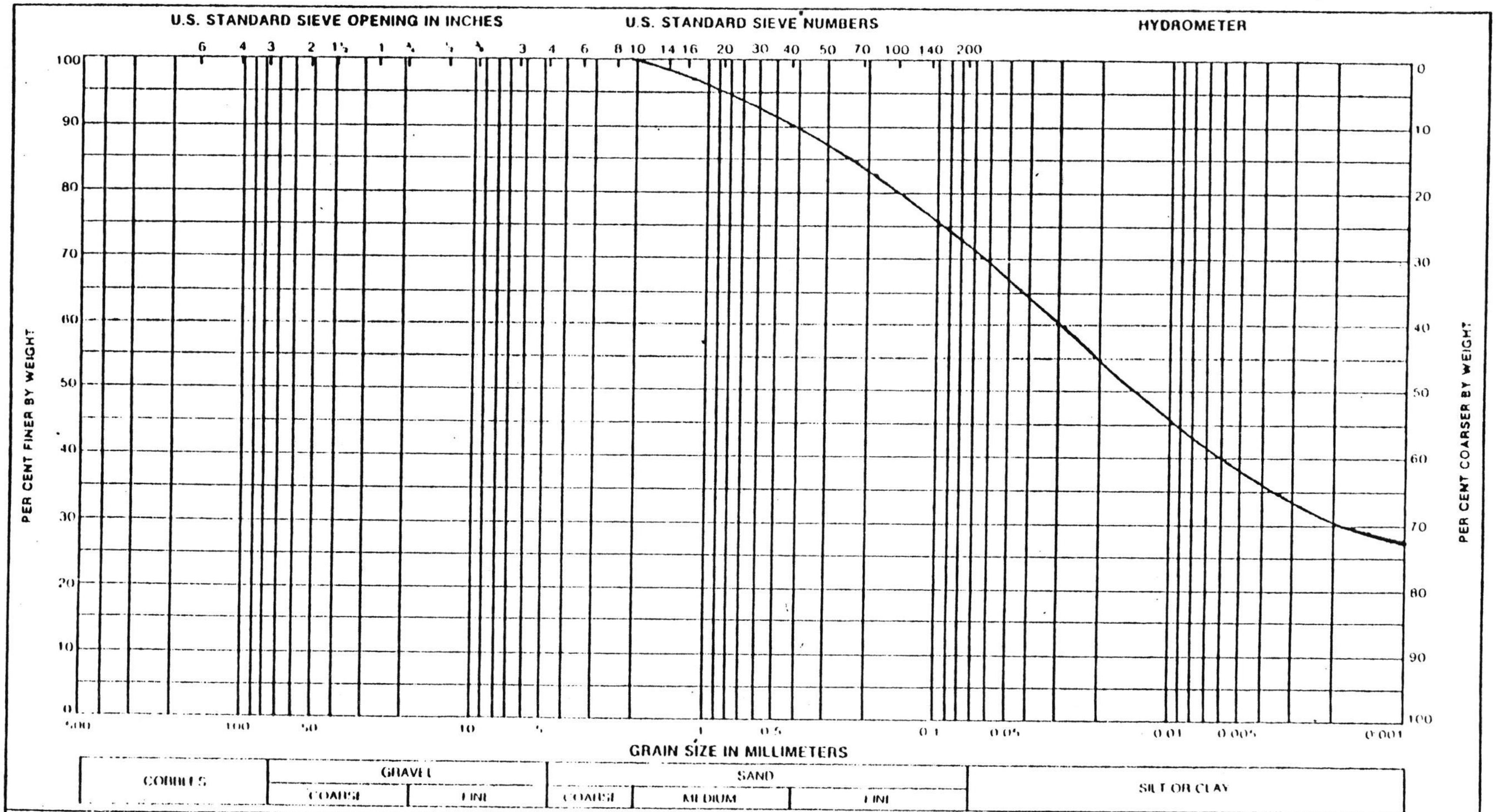


APPENDIX D

Glacial Till Grain Size Curves

and

Laboratory Hydraulic Conductivity Test Results

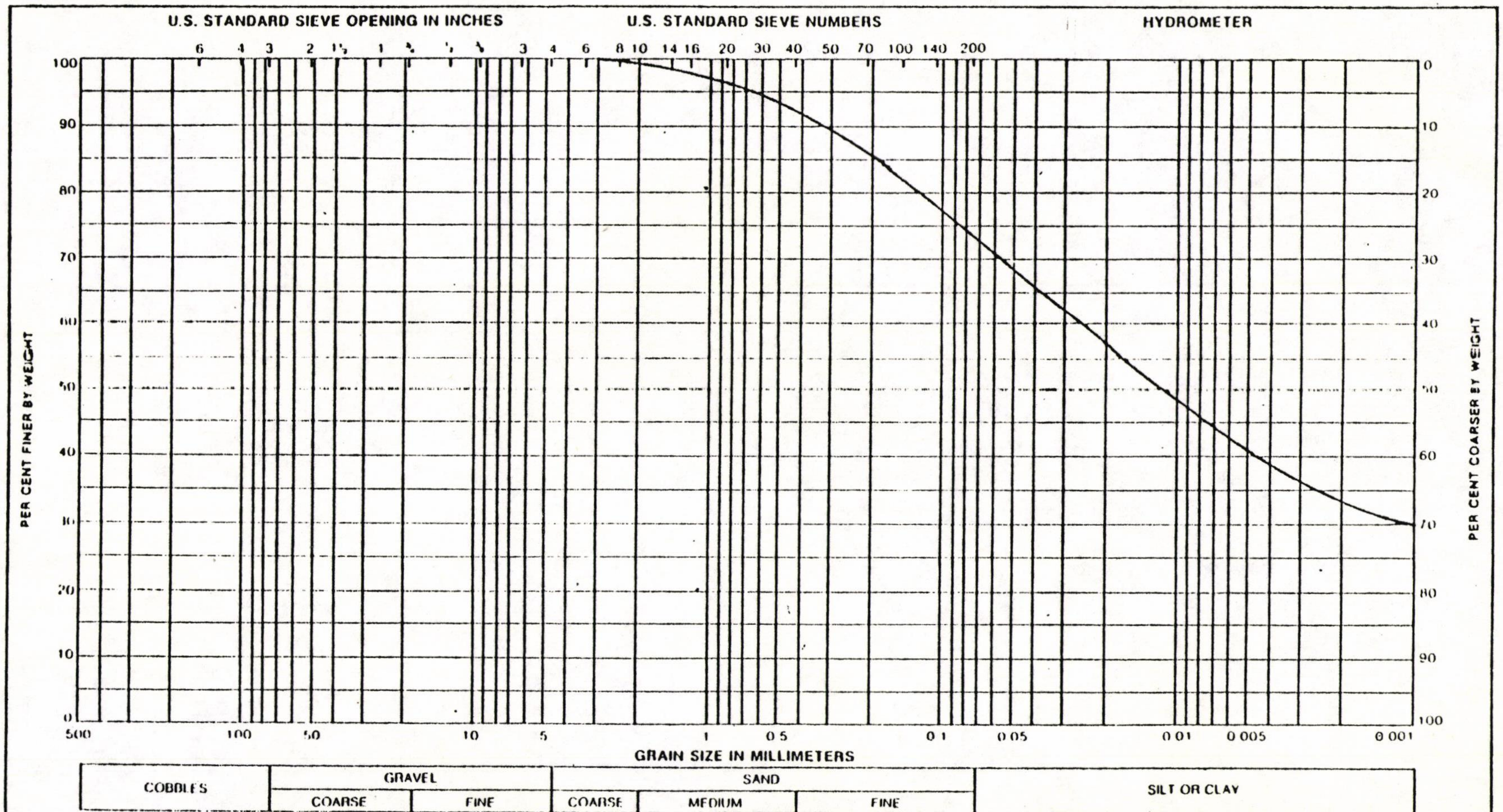


Boring No	Sample No	Elev. or Depth	Classification	Nat w %	LL	PL	PI	Project
MW2-D	8	35½-37	Grey Slightly Sandy Fat Clay, Glacial Till	20.1	--	--	--	Monitoring Wells Maryville, Missouri
			HYDRAULIC CONDUCTIVITY 5.0 x 10⁻⁷ cm/sec					

REPORT OF SOIL ANALYSIS

File No 172-55101

Professional Service Industries

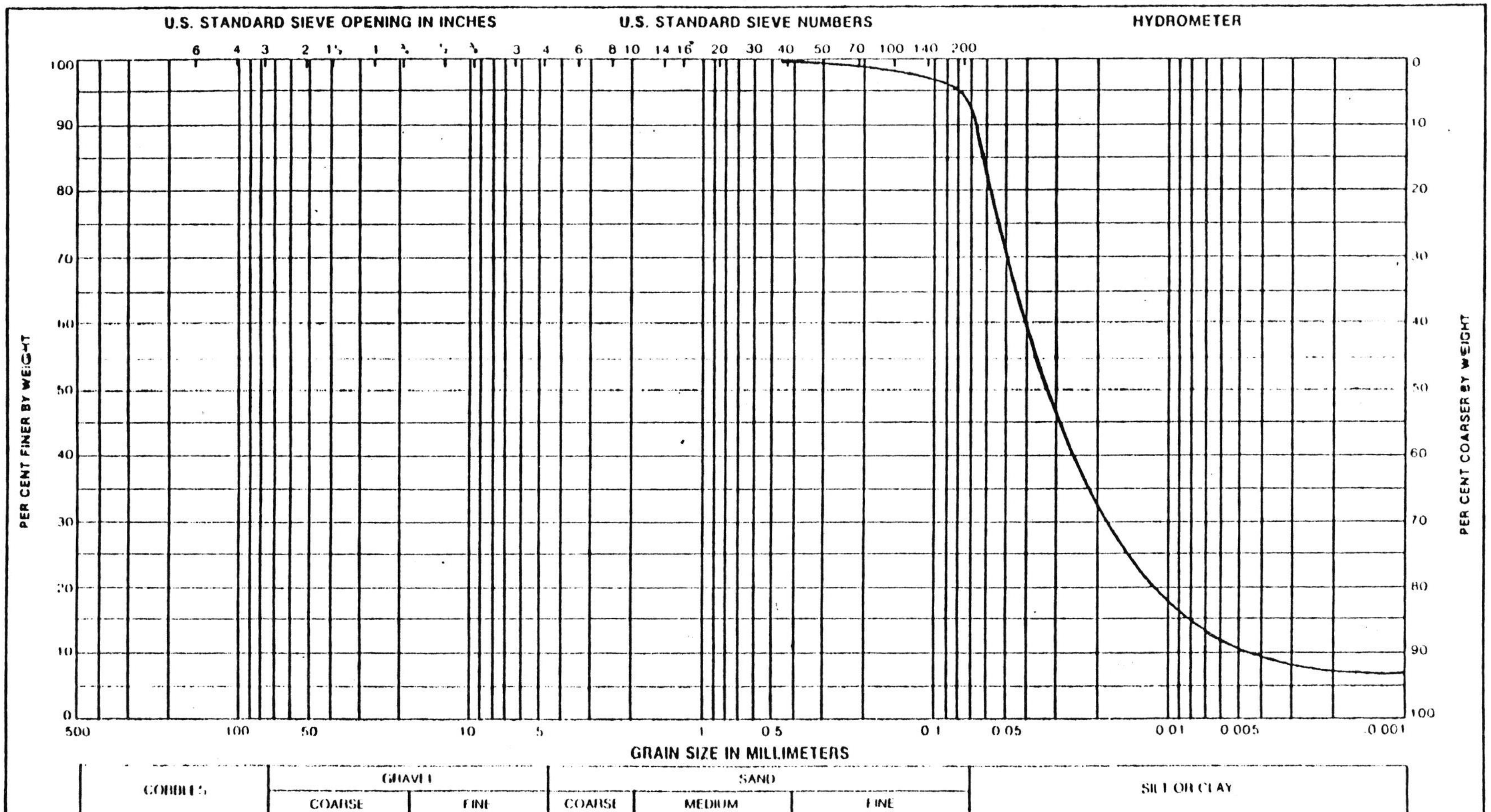


Boring No.	Sample No.	Elev. or Depth	Classification	Nat w %	LL	PL	PI	Project
MW4-D	9	39½-41	Grey Slightly Sandy Fat Clay, Glacial Till	19.9	--	--	--	Monitoring Wells Maryville, Missouri
			HYDRAULIC CONDUCTIVITY - 7.9×10^{-8} cm/sec.					

REPORT OF SOIL ANALYSIS

File No 172-55101

Professional Service Industries

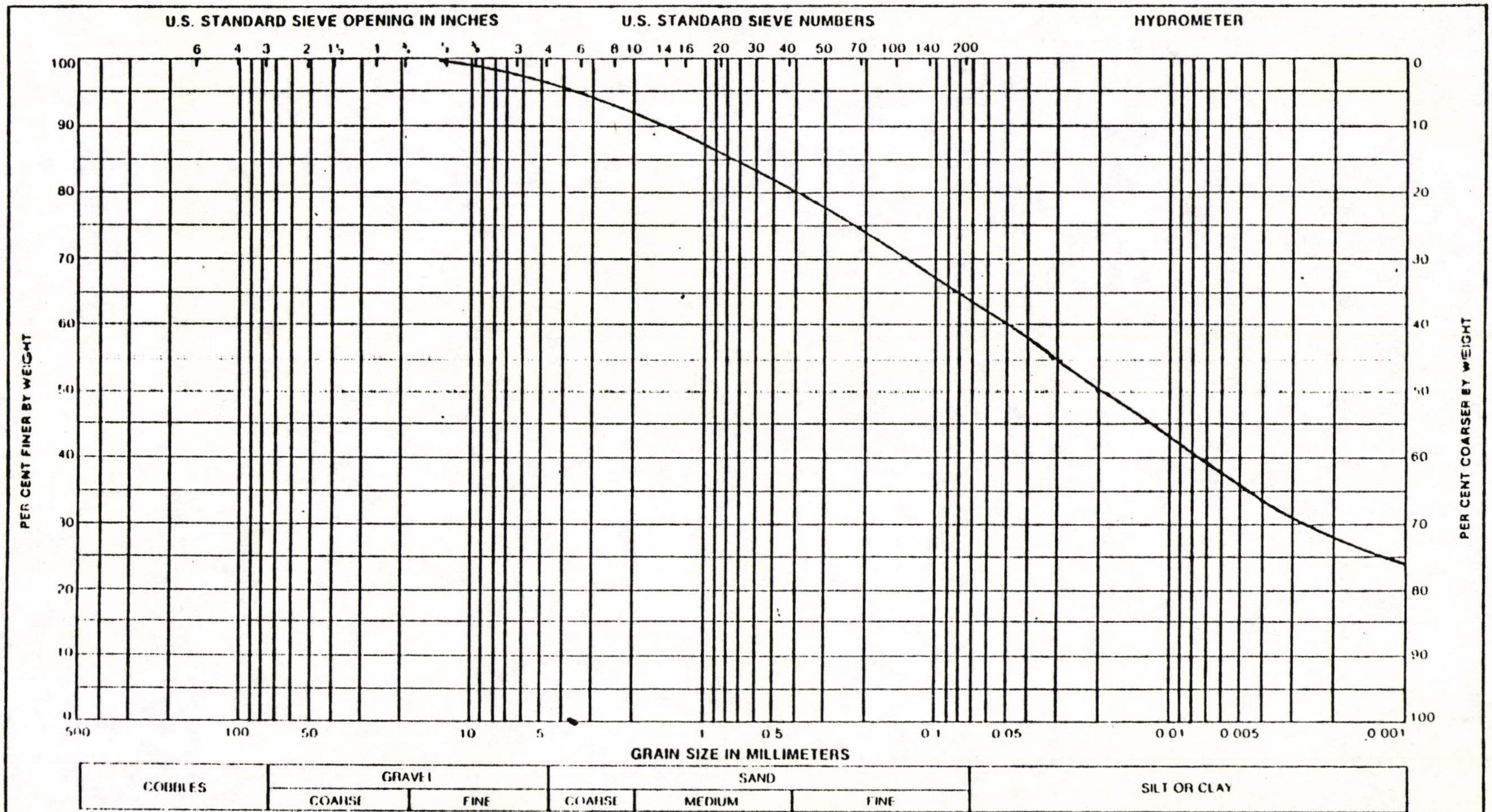


Boring No.	Sample No.	Elev. or Depth	Classification	Nat w %	LL	PL	PI	Project
MW7-D	8	45-46½	Grey Silt with Fat Clay Layers, Glacial Till	21.3	--	--	--	Monitoring Wells Maryville, Missouri
			HYDRAULIC CONDUCTIVITY— 8.1×10^{-7} cm/sec					

REPORT OF SOIL ANALYSIS

File No 172-55101 Page 4

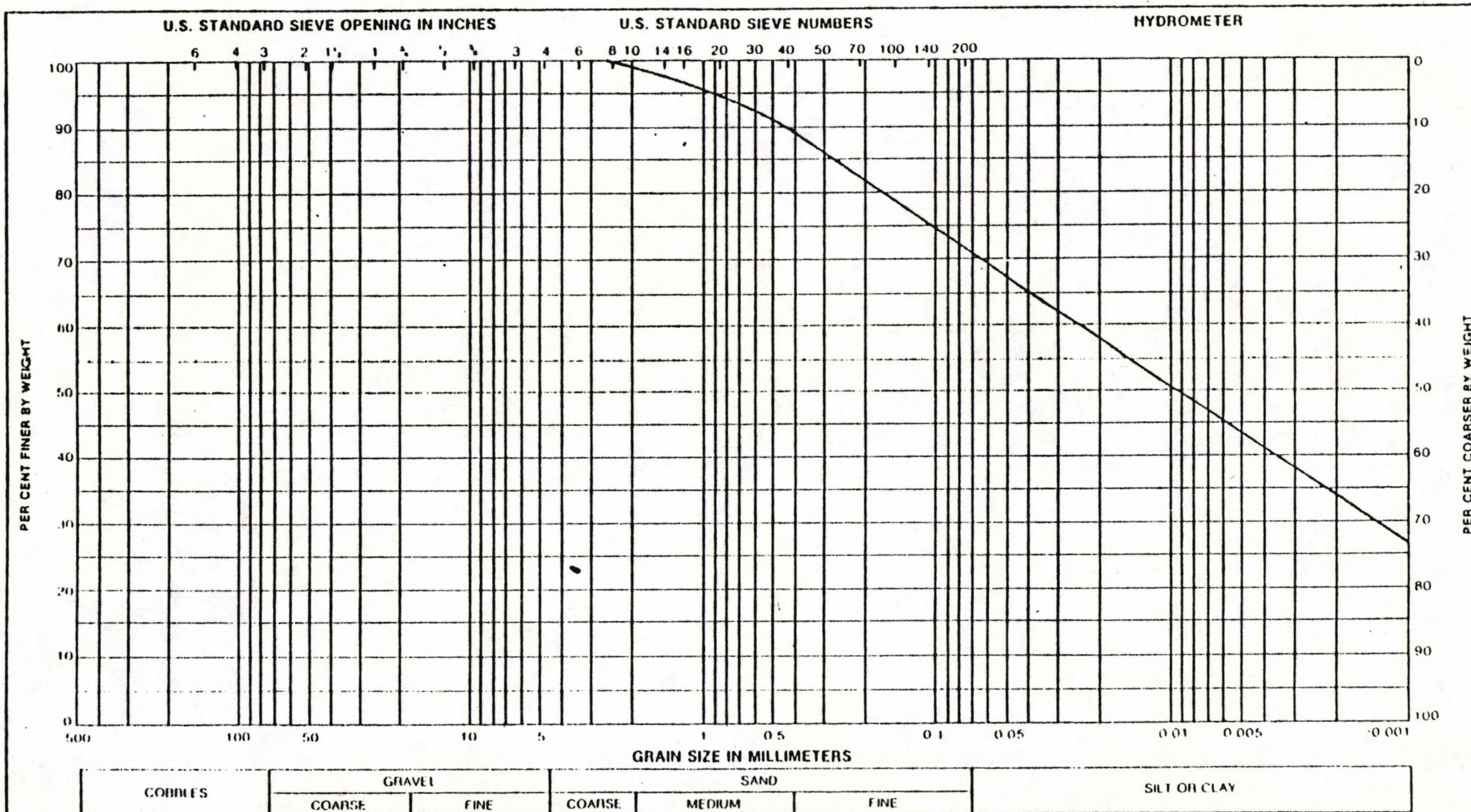
Professional Service Industries



Boring No.	Sample No.	Elev. or Depth	Classification	Nat w %	LL	PL	PI	Project
MW7-D	7	30-31½	Grey Sandy Fat Clay, Glacial Till	21.2	--	--	--	Monitoring Wells Maryville, Missouri
			HYDRAULIC CONDUCTIVITY- 1.3×10^{-6} cm/sec					

REPORT OF SOIL ANALYSIS

File No 172-55101 Page 3



Boring No.	Sample No.	Elev. or Depth	Classification	Nat w %	LL	PL	PI	Project
MW8-D	8	35-36½	Grey Slightly Sandy Fat	20.5	--	--	--	Monitoring Wells
			Clay, Glacial Till					Maryville, Missouri
			HYDRAULIC CONDUCTIVITY – 1.2 x 10^{-7} cm/sec					

REPORT OF SOIL ANALYSIS

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